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Mediterranean Fruit Fly Parasite Expeditions

1935-1936

[1939]

West Africa

East Africa

Brazil

Malaya, Ceylon and India





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REPORT OF AN EXPEDITION TO WEST AFRICA IN SEARCH OF  
FRUIT FLY PARASITES (1935-1936).

R. H. Van Zwaluwenburg

*J. M. McGough*

In September 1935, the writer, with James M. McGough, was authorized to proceed to West Africa to obtain, and ship to the Hawaiian Islands, parasites of fruit flies (Trypetidae) which might be useful in improving the natural control of the Mediterranean fruit fly (Ceratitis capitata (Weidemann)). Similar expeditions to the same part of the world had been made by Prof. F. Silvestri of Naples in 1912-1913, and by Messrs. D. T. Fullaway and J. C. Bridwell in 1914. Both expeditions were under the auspices of the Hawaiian Territorial government. Dr. Silvestri spent a year investigating fruit flies from Senegal to Cape Colony, returning to Hawaii by way of Australia. Messrs. Fullaway and Bridwell spent about six weeks at Olokemeji, Southern Nigeria, to continue Silvestri's work and to obtain some of the parasite species discovered, but not established, as a result of the Italian scientist's work. The net result of these expeditions was the establishment in Hawaii of the following species, all parasitic upon the larval stages of fruit flies:

Braconidae: Opius humilis Silvestri from Cape Colony  
Diachasma fullawayi Silvestri from West Africa  
Diachasma tryoni (Cameron) from Australia

Chalcididae: Tetrastichus giffardianus (Silvestri) from  
West Africa

In addition, two pupal parasites, Galesus silvestrii Kieffer (Prototrupididae) and Dirhinus giffardi Silvestri (Chalcididae) were bred from West African fruit fly species, and distributed in large numbers in the Hawaiian Islands, but resulted in no permanent establishment there of either species. For this reason, its time being sufficiently occupied with obtaining parasites of larval stages of fruit flies, the present expedition paid little attention to the further possibilities of pupal parasites.

Mr. McGough and the writer sailed from New York on the SS MANHATTAN on October 9, 1935, arriving in Plymouth, England on October 15. Proceeding to London, in company with Messrs. F. A. Bianchi and Noel Krauss, who were en route to East Africa on a like project, contact was made with Sir Guy A. K. Marshall, Director of the Imperial Bureau of Entomology. Dr. Marshall arranged an introduction to Mr. F. A. Stockdale, Agricultural Advisor to the Colonial Office, and from the latter gentleman we got much valuable information relative to West



Africa. Fortunately Mr. Stockdale, accompanied by his secretary, Mr. I. M. R. MacLennan, sailed from Liverpool for West Africa on the same ship as ourselves, the SS APAPA, which left October 30, and we had the advantage of closer acquaintance with his intimate knowledge of agricultural conditions in the British West African colonies.

The itinerary of the expedition in West Africa was as follows:

Sierra Leone, November 9 - April 4

Mr. McGough returned to the United States with a shipment of material on January 16, returning to Freetown on April 4.

Liberia, April 6

Ivory Coast, April 10-11

Gold Coast, April 14

Nigeria, April 17 - May 17

French Cameroons, May 20 - June 20

At this point the expedition divided permanently, Mr. McGough remaining in the French Cameroons until the middle of August before returning direct to the United States. The following outlines the movements of the writer after leaving French Cameroons.

Angola, June 26 (Loanda) and June 28 (Lobito)

Belgian Congo, July 2-6

Gold Coast, July 14-15

Sierra Leone, July 23-28

Return to the United States, August 13 (Philadelphia)

En route to Sierra Leone the first stop was at Funchal, Madeira, where a four-hour layover on November 4 allowed of a visit to the local market. Avocados, oranges and mangoes were available, but no infested fruits were found. We learned that peaches, a fruit commonly infested by Mediterranean fruit fly in Madeira, would not come upon the market until December.

#### Sierra Leone

Arriving at Freetown, Sierra Leone late on the afternoon of November 9, Mr. Stockdale introduced us to Dr. F. J. Martin, the Director of Agriculture. A few days were necessary to prepare for travel in the interior, and during that time fruits were examined in the markets and gardens of Freetown. On the morning of November 15 we proceeded by train to Njala, about 100 miles almost due east of Freetown, where the facilities of the Department of Agriculture's experimental farm were placed at our disposal through the courtesy of Dr. Martin.



The Njala farm consists of several hundred acres lying on both sides of the Taia River, devoted to experimental work with native food crops, those of commercial value, and plants which promise to be valuable to Sierra Leone agriculture. The staff at the time of our visit consisted of Mr. Ernest Hargreaves, entomologist, Mr. F. C. Deighton, mycologist and Mr. G. M. Roddan, agriculturist. All of these gentlemen were of the greatest assistance to our work.

The vegetation about Njala, and throughout most of southern Sierra Leone, consists of orchard bush. The growth is secondary, the native method of cultivation depending upon cutting and burning off the bush for small plantings which are farmed for about a year. After harvest the plantations revert back to bush which consists of native trees and shrubs; after the usual five or six years have elapsed before the next clearing and planting, the bush has become so thick that access through it can be had only where paths have been kept open. The original forest cover has long since disappeared. Introduced food plants are commonly planted in the vicinity of villages.

Infested fruits were collected in the vicinity of Njala, and with the material obtained we returned to Freetown on December 7. Work there continued until April 4, long beyond the time originally planned, due to the unfortunate halting of the program as a project under the Agricultural Adjustment Administration. From January 3 to 11 the writer was again at Njala, collecting fruits for Mr. McGough to take with him when he sailed to the United States on January 16. A resume of the results of this and other shipments of parasites is given in a later paragraph.

On July 23 the writer returned to Freetown on the SS PADNSAY after an absence down the West Coast, and after collecting a quantity of available fruits, sailed for the United States on the SS WEST HUMHAW on July 28.

Nearly 10,000 native and introduced fruits of about 100 kinds examined in the Freetown and Njala districts were uninfested by fruit flies. In fact, infestation was confined to a comparatively small number of host species, most of them indigenous African plants. These were as follows:

Cucumbers - Obtainable in Freetown and Njala throughout the year, this vegetable is very commonly infested by Tridacus near pectoralis Wlk. (SL-1). Infestation was sometimes severe, and large numbers of Dacus were reared; we obtained nearly 100% emergence of flies. From 400 puparia obtained in December were bred 3 Opius sp., but in some lots not a single case of parasitization occurred in fruit flies infesting cucumbers.



Passiflora foetida L. - This is another non-African plant very widespread and common in West Africa. Fruits ripen throughout the year, and seldom drop to the ground even when infested by trypetids. We reared from this host only one species of fruit fly, Dacus punctatifrons Karsch. (SL-4). At Njala in November infested fruits were easily obtainable, but there was only a single case of parasitization (by Tetrastichus giffardianus (Silv.)) out of 1356 puparia. At Freetown no parasites were bred from this fruit.

Sarcocephalus esculentus Afzel - Family Rubiaceae; native names "yumbuyambe", "igbessi"; Freetown Creole name: "Sierra Leone peach". This plant which is a tall tree under forest conditions, but a scandent shrub attaining 20 feet in height in the orchard bush and savannah regions, has a natural range of from Senegal to Angola, Eastern Sudan and Uganda. The fruit, dark red when ripe, is from 1 to 3½ inches in diameter, and has two main ripening seasons yearly in southern Sierra Leone, one from November into February, and the other from May into August; a few ripe fruits can usually be found at almost any time of year.

The only trypetid bred by us from this fruit was Ceratitis giffardi Bezzi. Oviposition takes place even when the fruit is immature and very hard, and the infestation at least at Njala and Freetown, is usually fairly heavy. Sarcocephalus fruits at Njala in November showed 42.8% parasitization by three species:

Biosteres caudatus Szepi. 21.7% (72 males, 133 females)  
Opius perproximus Silv. 16.9% (4 males, 12 females)  
Tetrastichus giffardianus (Silv.) 4.2%

Another species of Sarcocephalus, S. diderrichii de Wild., a large tree with a similar but smaller fruit, was uninfested at Njala in November, but further work with this species might be profitable. It has a crop maturing in November and December, but we do not know if there is a second crop during the summer months.

Chasalia afzelii K. Schum. - Family Rubiaceae. This shrub is apparently confined to Sierra Leone, but is uncertain if it is an indigenous African species. The fruit, which was found ripe at Njala in November, is a small black berry. From 40 berries were obtained 28 puparia of Trirhithrum coffeae Bezzi (SL-24), and four females of a small, all-black braconid, (Opius sp.). Although the plant was common in January along the road leading from Hill Station to Regent, we never again found any infested berries.

Luffa cylindrica Roem. - Family Cucurbitaceae. An introduced plant common throughout the tropics, fruit was available at Njala in November. From it was reared Tridacus sp., near pectoralis Wlk. (SL-7), but no parasites. An adult of Dacus punctatifrons Karsch., was seen resting on a vine of this species.



Mormodica charantia L. - Family Cucurbitaceae. An introduced plant common in the tropics. From its fruits were reared specimens of Dacus near punctatifrons Karsch and D. brevistylus Bezzi at Freetown in July; no parasites were reared from this material.

Cola nitida A. Chev. - Family Sterculiaceae. Common in Sierra Leone, this is not the cola of commerce. Ripening fruits were got at Njala in November, but none was infested. Fruits collected at Regent, near Freetown, in December were infested by fruit flies (SL-31), but no parasites were obtained.

Conopharyngia longiflora Stapf. - Family Apocynaceae. This plant (cited by Silvestri as Plumeria longiflora) is indigenous to Africa, and occurs from Senegal eastward to the Ivory Coast. The fruit, bright yellow when ripe, is round with a diameter up to about three inches, and is usually borne in pairs on a common stem. In southern Sierra Leone ripe fruits were most common from November to February, but a few can usually be found the year round. The only trypetid reared from this fruit was Ceratitis punctata (Weidemann) (SL-11); infestation was usually rather light. Oviposition occurs while the fruit is still green, despite a very copious flow of latex following injury to the immature fruit. Infested fruits seldom show any blemish or sign of latex flow on the surface, so it is probable that oviposition takes place under the calyx. Puparia of C. punctata from Conopharyngia yielded Opius perproximus Silvestri and Hedylus giffardi Silvestri, in fair numbers, but no data on percentage of parasitization in this fruit are available.

Adenia lobata Engl. - Family Passifloraceae. An indigenous, tall, woody climber ranging from Senegal through Nigeria and the Cameroons to Spanish Guinea and Angola. In Sierra Leone fruits were ripe at Njala in November, and in the Hill Station region near Freetown in July. The only fly (SL-17 & SL-28), bred was from this host Tridacus sp. near pectoralis Wlk. No parasites were obtained. Infestation is seldom severe, and for some unknown reason there is a fairly high mortality of the maggots in the field.

Coffea liberica Bull ex Hiern - Family Rubiaceae. Cultivated from Senegal to Angola, and said to be indigenous around Monrovia, Liberia. Berries collected at Regent in December were lightly infested and yielded a few specimens of Trirhithrum coffea Bezzi (SL-32); from puparia was bred one specimen of Opius sp. (Associated either by host plant or by host insect number). No ripe berries were available during my second visit to Sierra Leone in July.

Cacao - Working with blackened, over-ripe pods of this widely-spread American plant, we obtained a single trypetid puparium from material collected at Regent in December, but the specimen died without issuing, and with no evidence of parasitization. Dr. Silvestri records Ceratitis punctata from cacao material, but because in our experience introduced plants were not productive of parasites, we devoted most of our effort to work with indigenous hosts.

Chrysophyllum pruniforme Engl. - Family Sapotaceae. An indigenous species occurring from Sierra Leone to Angola in West Africa, and from Kenya to Natal. A tall tree found in the forest with a single crop (December to March in Sierra Leone) of round fruits having a diameter of something over one inch. Infestation of fallen fruits by Ceratitis punctata (Weid.) (The only fly reared from this host) was extremely heavy, nearly all the fruit being infested and an incomplete record showing an average of almost 18 maggots per fruit. Material from this tree proved the most productive of parasites of any of the fruits we worked with. Puparia collected during December near Freetown showed 18.9% parasitization, a figure which would probably be higher had the fruits remained accessible in the field to ovipositing parasites instead of being kept indoors. Opius perproximus Silvestri was the dominant parasite, with a parasitization of 17.4% (228 males, 471 females).\* Hedylus giffardi Silvestri, with 0.5% was the next most abundant parasite from this source, while from 4,007 puparia two cases were recorded of parasitization by Tetrestichus giffardianus (Silvestri).

From 19,751 puparia of C. punctata obtained January 18-February 6 from Chrysophyllum, the following parasite emergence occurred:

<u>Opius perproximus</u> Silv.	12.6% (855 males, 1635 females)
<u>Hedylus giffardi</u> Silv.	1.1% ( 50 males, 172 females)

It is obvious that Opius vastly outnumbers Hedylus in these two instances, the sum of both records being: Opius 3189, Hedylus 244.

Anisophyllea laurina R.Br. - Family Rhizophoraceae. An indigenous species which occurs in French Guinea, in Sierra Leone and southern Nigeria. In Sierra Leone at least it is confined to the coastal region, not at sea-level but up to 800 ft. In Sierra Leone about Freetown, where it is very numerous at Hill Station, it ripens in March. There is but one crop of fruit a year. Ceratitis annonae Grah. (#100) was bred from this fruit; in addition a few specimens of Opius were reared, but before they could be determined ants got into the breeding container and devoured them. The percentage of parasitization was very low, although the infestation of fruit was fairly heavy.

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\*A very few individuals of what later proved to be Diachasma fullawayi Silvestri, are included in these figures, due to failure to distinguish the species while handling the living material in Sierra Leone; however, the above figures are approximate for O. perproximus.



### Liberia and Ivory Coast

Two hours were available ashore at Monrovia, Liberia on April 6, but advantage was taken of this brief opportunity to visit the local markets for fruit. Nothing was found but a few oranges, and no infested fruit was seen.

Approximately 24 hours was spent ashore in the Ivory Coast on April 10-11, both Abidjan and Grand Bassam. Citrus was examined at markets, and along roadsides ripe nuts of a species of *Terminalia*, whether indigenous or not could not be learned. Neither of these was infested. Although there is a heavy growth of forest along the coast, the writer was unable to find in it any fruits for examination.

### Gold Coast

Part of a day was spent here at Accra on April 14, in company with Mr. G. G. Auchinleck, Director of Agriculture. A few fruits, mainly citrus, were examined, but no infested ones were found.

Returning to the Gold Coast in July, the 14th and 15th were spent in excursions to the Agricultural Department's stations at Aburi and Asuansi. At Aburni I examined ripe surinam cherries and *Spondias monbin* L., both tropical American species, but could find no infestation. In the entomological collection I saw adults of *Ceratitis capitata* (Weid.) determined by Dr. G.A.K. Marshall, and bred from citrus by Mr. G. S. Cotterell, the entomologist; there were also in the collection adults, swept from citrus, of *C. punctata*.

Proceeding to Asuansi on the afternoon of the 14th, I spent the night there, and the following day with Mr. C. W. F. Line, the officer in charge, and Mr. W. F. Steven, Mycologist, examined a number of fruits.

Ripe fruits examined were: *Momordica foetida*, *Averrhoa*, *Spondias mombin* and *Chrysophyllum* sp.; none was infested. The *Chrysophyllum*, a purple-fruited species, was the only ripe fruit on a tree which had in February borne a heavy crop of fruit, practically all of which was now hanging dry on the tree. This offered an interesting example of out-of-season fruiting whereby a trypetid, even if specific upon a single host fruit, might survive the hazards of dependence upon a single main annual crop. A few immature fruits of *Conopharyngia* sp. and of *Myrianthus arboreus* P. Beauv., were also examined, but proved to be uninfested.

## Nigeria

We arrived at Lagos, Nigeria on April 17, and as soon as arrangements could be made with the colonial authorities, proceeded on the 22nd to Moor Plantation, the experimental farm of the Department of Agriculture four miles west of the city of Ibadan, about 125 miles north of Lagos. Here facilities were given us by Mr. O. T. Faulkner, the Director, and we had the benefit of valuable assistance from Mr. F. D. Golding, the entomologist.

The country about Ibadan, while originally well-forested, is now largely covered by orchard bush following the usual clearing by natives for purposes of planting. A few native fruits, some of them ripe, were found in considerable quantity, but none was infested. The only trypetid-infested fruits found were of Momordica (prob.) charantia L., a cucurbitaceous plant common in the tropics. From this was bred Dacus brevistylus Bezzi (#110), and the following parasites in order of their abundance, about 50 in all:

Opius sp. (reddish body, black head)  
Braconid (with ovipositor comparable in length to that of Hedylus)  
Biosteres caudatus Szep.

The percentage of parasitization was high (approximately 50%), and had more Momordica been obtainable a parasite shipment might profitably have been made.

Three species of Ceratitis and two of Dacus (101) Dacus vertebratus Bezzi, Dacus ciliatus Lw. (102) Ceratitis sp. (near cosyra Wlk.) C. capitata Wd. and (104) Ceratitis annonae Wlk., were swept from foliage of the leguminous Gliricidia maculata used as a windbreak at Moor Plantation, these flies, together with numerous other Diptera and Hymenoptera, apparently being attracted to the nectarines on the stems of the plant. Lule corioptera Speiser was swept from foliage of an unknown plant in the vicinity of Moor Plantation.

On May 6 we moved the work to the Nigeria Forest Reserve at Olokemeji, some 30 miles west of Ibadan, a reservation of about 25 sq. mi., where through the courtesy of Mr. Weir, Acting Director of Forests, we had the use of the Director's bungalow. The reserve consists of fringing forest and orchard-bush, and is much heavier and richer in species than the cultivated country about Ibadan. We are indebted to Mr. Collier, Ibadan Circle Forest Officer and to Mr. Littlejohn of the forestry staff for identifications of plants. Although, as at Moor Plantation, the season clearly was not the most favorable for finding mature wild fruits, we did obtain the following plants infested by fruit flies:



Napoleona (prob.) vogelii Took. & Planch. - Family Lecythidaceae; Yoruba name; "boi-boi". A shrub or tree up to 50 ft. high, widely spread, probably from Sierra Leone to southern Nigeria. The fruit, yellow when ripe, a few of which were obtained in May, but ripening mainly in July in southern Nigeria, is depressed globose, five-celled, with one kidney-shaped seed in each. From this fruit were bred Ceratitis punctata Ed., (#115) and Conradina acroleuca Ed. (#114). From the puparia of one or both flies were obtained one specimen of each of the following, both apparently the same as the species from Dacus brevistylus Bezzi (#110) in Momordica at Ibadan:

Hedylus-like Braconid with long ovipositor  
Opius sp. (reddish body, black head)

The parasitization totalled less than 5.0%.

Lanslophia sp. - Family Apocynaceae; a vine, the latex of which is sometimes used as a source of commercial rubber. Only two ripe fruits were obtained, from which were bred specimens of Ceratitis punctata (Wied.) (#112), but no parasites.

?Adenia sp. - A passifloraceous vine, unknown to the forest officers, but very much resembling Adenia lobata of Sierra Leone. From the few fruits obtained were bred Tridacus pectoralis Wlk. (#117) in considerable numbers, but no parasites.

Cononcherynia penduliflora Stapf. - Family Apocynaceae; Yoruba name; "ibu". Only a few fruits were obtainable from which were bred numerous ?Ceratitis tritea Walker (#111), but no parasites.

Unknown fruit - Said to have been planted in the forest, doubtful whether or not indigenous to some other part of Africa. From the single fruit obtained were bred a dozen Ceratitis annonae Grah. (113); but no parasites were obtained.

In addition to the above reared material two trypetids, Carpophthoromyia n. sp. (#107), Ceratitis capitata d. (#109) were swept from vegetation along forest paths, and Dacus rufus Bezzi ? (#108) from souring pods of Sterculia sp. along a shady forest path.

It is probable that had we been able to get to Nigeria earlier in the year more ripe native fruits could have been gotten, and more parasites obtained. None of the infested fruits was numerous, even of Momordica, while we saw plenty of evidence that earlier many fruits, (notably Chrysophyllum) had been ripe.

French Cameroons

We arrived at Douala, French Cameroons, early on the morning of May 20, on the SS WEST KEBAR. The surrounding country is low and flat, with mangroves lining the lagoons and rivers; immediately back from the water there is high forest, not virgin for the most part, but cut so long ago that it has recovered much of its original luxuriant growth. It is very thick and difficult to penetrate without cutting paths. For miles in the vicinity of the town the forest has been almost entirely cleared for agriculture. The rainfall is very heavy (over 200 inches a year) and since the rains were said to have just begun, we found no infested fruit about Douala during the first week that we were there. Despite the apparent absence of infested fruits the black and white Carpophthoromyia n. sp. (#118) was common everywhere along forest roads and clearings. Single specimens of three other species Ceratitis cosyra Wlk. (#119, & #120) (#121) were also taken in a forest clearing near the town.

On the 27th we went to Yaounde, a town some 200 miles east of Douala, which at an elevation of some 2500 feet, is located on the margin between the rain forest and the grassy savannah belts. The rainfall here is only about 50 inches yearly, and the climate is the best we found anywhere in West Africa. We swept from vegetation along roads or forest paths not less than four species of Trypetids (#122) Carpophthoromyia n. sp. (#123) Bistrispinaria fortis Speiser (very likely a Ceratitis) (#124) Ceratitis sp. (near cosyra) (#125) Ceratitis punctata Wlk. and C. annonae Grah.

Forest fruits appeared to be coming into season, and among numerous species, most of which were not infested, we found the following species with trypetid infestations:

Myrianthus arboreus P. Beauv. - Family Moraceae; Yaounde name: "ngakom". A large tree usually in damp places in the forest ranging from Sierra Leone eastward to Uganda, and south to Angola. The large composite fruit, yellow when ripe, attains a diameter of four or five inches; this fruit was just ripening during our stay in Yaounde from latter May into early June. Only a single trypetid (#131) Ceratitis annonae Grah., was reared from this fruit, but infestation was fairly heavy, about 50% being infested. The following hymenoptera were bred from this material:

Tetrastichus giffardianus (Silvestri)

Biosteres caudatus Szep. This determination is open to some doubt, but aside from being generally darker than the B.

caudatus obtained in Sierra Leone it is apparently the same. Hedylus-like braconid with long ovipositor and black head; general color reddish.

Probable hyperparasite (2 specimens).



A group of not less than 1000 puparia from Myrianthus showed a total parasitization of not less than 50%; 17.5% of the parasitization was due to Tetrastichus.

Conopharyngia spp. - This apocynacoccus fruit also was apparently at the beginning of its ripening season. From it was bred Ceratitis punctata Wlk. & C. annonae Grah. (#128) and the black and white species so common about Douala. Carpophthoromyia n. sp. (#127). Infestation was by no means heavy. The following parasites were reared from Conopharyngia material:

Tetrastichus giffardianus

Biosteres, identical with that from Myrianthus

Hedylus-like braconid, reddish, with both head and abdomen black.

Cola sp. - A few fruits of cola were found in the forest, heavily infested by Ceratitis annonae Grah. (#130). From it were reared the same Biosteres and the same Hedylus-like species as were obtained from Conopharyngia.

Unknown fruit - Yaounde name: "mbazo'o"; the fruit of a tall forest tree with leaves suggesting the walnut, is about the size, shape and color of a large olive. Few fruits were infested, but those fairly heavily, by Tridacus humeralis Bezzi. (#132). From it were bred the same Biosteres as from the preceding fruits, and a single female specimen of a reddish Opius.

Avocado - A few heavily infested fruits of this introduced plant were obtained from a native some ten miles south of Yaounde. Ceratitis annonae Grah. (#129) were bred from this material, but no parasites.

On June 9 we returned to Douala with a large quantity of Yaounde fruits, mainly Myrianthus, intending to sail for the Belgian Congo on the 20th. A few days before sailing, emergence of parasite material from Yaounde began, and the prospects were so promising that it was decided to have Mr. McGough return to Yaounde for further work there. According to present plans he should sail from the Cameroons direct to the United States on August 12.

Further search in the forests about Douala, from July 10-19, resulted in finding a single trypetid-infested fruit of an unknown tree. The fruit was green with white stripes, and suggested in shape those of species of Randia seen in Sierra Leone. Unfortunately the maggots within the fruit died without pupating.

### Angola

Enroute to Matadi in the Belgian Congo from Douala, Loanda and Lobito were visited on June 26 and 28 respectively. The country surrounding both of these towns is very dry (14 and 9 inches of rain a year, respectively) and fruits were confined mainly to those found in markets, and originating in the interior of the country. Near Lobito a few sweetsops were found growing, but at neither port were any infested fruits seen.

### Belgian Congo

On July 2, I arrived at the town of Matadi, about 80 miles up the Congo River. The dry season had been in effect for something like a month, and the countryside was very dry. There are few trees in the vicinity, and little vegetation except tall dry grass. The only fruits found to a distance of 20 miles to the southeast were a few Momordica, which were infested. From these a few individuals of Dacus n. sp. (near chrysomphalus) (#122) were bred, but no parasites.

So far as can be judged from the coast, the rain forest in West Africa extends southward to about the mouth of the Congo. To the north of the river in Congo territory, trees are scattering, while to the south, in Angola, the wide grassy plains are practically without trees or shrubs of any kind. Near the river mouth the banks of the Congo have a fairly high growth (30-40 feet) of trees consisting mainly of mangroves, which here attain a height I have not seen elsewhere. A few miles up-river this tree growth disappears, the banks being covered with high grass and papyrus, with a few Borassus palms in the background. The lower river is dotted with small islands, low, flat and grass-covered, and subject to inundation in the rainy season. As Boma, some 40 miles up the river, is approached, low hills begin to appear; these also are covered with tall grass; the valleys between the hills are marked by clumps of trees. As one proceeds up-stream the hills increase in size until, at Matadi, they are of considerable height; their vegetation is the same as farther down-river, with the gradual addition of baobab trees. Back of Matadi the hills are broken by stony cliffs, and the general appearance at this season is of a semi-arid country. In gulches between the hills native agriculture is carried on, plantings of trees such as mango and avocado being interspersed with corn, cassava, etc. Ruphorbias and spiny legumes dot the hillsides. The rain forest is said to begin along the river somewhere between Leopoldville and Matadi.

### Shipments of Parasites



Following is a summary of the shipments of parasites from West Africa to Hawaii:

<u>Species</u>	<u>Date Shipped</u>	<u>Immediate destination</u>	<u>Via</u>	<u>Number shipped</u>	<u>No. alive on arrival</u>
<u>Opius perproximus</u>	Dec. 18	Boston	Steamer	15	0
	Dec. 30	England	Steamer	99	1
	Jan. 16	Philadel- phia	Person- ally con- ducted	324	250
	Feb. 1	Boston	Steamer	180	0
	Feb. 7	LeHavre	Steamer	170	25
	Feb. 25	Philadel- phia	Steamer	153	10
	Mar. 15	Marseilles	Steamer	57	0
<u>Hedylus giffardi</u>	Jan. 16	Philadel- phia	Person- ally con- ducted	43	26
	Feb. 1	Boston	Steamer	20	0
	Feb. 7	LeHavre	Steamer	30	4
	Feb. 25	Philadel- phia	Steamer	59	9
	Mar. 15	Marseilles	Steamer	31	4
<u>Biosteres caudatus</u>	Dec. 18	Boston	Steamer	57	0
	Jan. 16	Philadel- phia	Person- ally con- ducted	427	220
<u>Biosteres ?</u>	July 5	Paris	Airplane	75	0

The shipment of January 16 was material taken by Mr. McGough personally on the SS WEST HUMHAW to Philadelphia.

#### KNOWN RIPENING SEASONS FOR WEST AFRICAN FRUITS FOUND TO BE INFESTED BY FRUIT FLIES

The following tabulation shows the periods at which infested fruits were found by us in West Africa; a few fruits, which though promising, were not infested, are included and marked with a single star (\*). A few records for the regions covered in this report have been added from the previous observations of Silvestri and Fullaway. These are marked with a double star (\*\*).

Sierra Leone

<u>Adenia lobata</u>	Njala	November, December
<u>Adenia lobata</u>	Freetown	July
<u>Anisophyllea laurina</u>	Freetown	March (1)
* <u>Agelaea trifolia</u>	Njala	December
* <u>Avocado</u>	Freetown	November, December
* <u>Blighia sapida</u>	Freetown	March
<u>Cacao</u>	Freetown	December
<u>Chasalia afzelii</u>	Njala	November, December
<u>Chrysophyllum pruniforme</u>	Freetown	December to February (1)
<u>Chrysophyllum sp.</u>	Freetown	December
<u>Coffea liberica</u>	Freetown	December, January
<u>Cola nitida</u>	Njala	November
<u>Conopharyngia longiflora</u>	Njala	November, December
<u>Conopharyngia longiflora</u>	Freetown	December, January, July
<u>Cucumber</u>	Freetown	November, December, July
* <u>Luffa cylindrica</u>	Njala	November
<u>Momordica charantia</u>	Njala	November, December
<u>Momordica charantia</u>	Freetown	December, January, July
<u>Passiflora foetida</u>	Njala	November, December
* <u>Psidium cattelalum</u>	Njala	November
<u>Sarcocephalus esculanetus</u>	Njala	November, December, January
<u>Sarcocephalus esculanetus</u>	Freetown	December, January, July

Gold Coast

* <u>Averrhoa sp.</u>	Asuansi	July
* <u>Chrysophyllum</u>	Asuansi	July (2)
** <u>Coffee</u>	Aburi	January
** <u>Cola sp.</u>	Aburi	January
* <u>Conopharyngia sp.</u>	Asuansi	July
** <u>Landolphia spp.</u>	Aburi	January
* <u>Myrianthus arboreus</u>	Asuansi	July (3)

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- (1) Fruits marked thus are known to have but a single annual crop.  
 (2) This was a single ripe fruit; the main crop ripened January to March, according to Mr. Line.  
 (3) This fruit was immature, and would probably have been ripe by August.



Nigeria

? <u>Adenia</u> sp.	Olokemeji	May
* <u>Chrysophyllum africanum</u>		
A.D.C.	Ibadan	February, March (4)
<u>Conopharyngia penduliflora</u>	Olokemeji	May
<u>Landolphia</u> sp.	Olokemeji	May
<u>Momordica charantia</u>	Ibadan	May
<u>Momordica charantia</u>	Olokemeji	May, July**, August**
<u>Napoleona vogelii</u>	Olokemeji	May
** <u>Oxyanthus tubiflorus</u> DC		
( <u>sulcatus</u> Hiern.)		
(Family Rubiaceae)	Olokemeji	November
** <u>Pyrenacanthus vogeliana</u> Baill.	"	November
** <u>Sarcocephalus esculentus</u>	Olokemeji	November

Cameroons

Avocado	Yaounde	May, June
Cola sp.	Yaounde	May, June
<u>Conopharyngia</u> spp.	Yaounde	May, June
"Mbazo'o"	Yaounde	May
** <u>Momordica</u> sp.	Victoria	January
<u>Myrianthus arboreus</u>	Yaounde	May, June
Unknown fruit	Douala	June

Belgian Congo

<u>Momordica charantia</u>	Near Matadi	July
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Immigrant vs. Indigenous Host Plants

In our experience, host fruits, introduced into West Africa, as distinguished from indigenous species, are seldom infested by trypetids. Even if infested, the parasitization of such material is usually unimportant; the only exception to this statement was the case of Momordica charantia collected near Ibadan, Nigeria. The only other non-indigenous fruits which produced parasites were cucumbers and Passiflora foetida; in each case parasitization was extremely low. Avocados, in the Cameroons, were infested by Ceratitis punctata, but without any parasitization. The more common introduced fruits like citrus, mango, papaya and the American Anonas we never found infested, and despite the years of work devoted by colonial scientists to citrus, there is only a single record of trypetids infesting fruit, that of Cotterell who bred C. capitata from citrus in the Gold Coast.

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(4) According to Mr. F. D. Golding.

Certain indigenous fruits, such as Coffea liberica and Anisophyllea, although infested, showed a disappointingly low parasitization. Other presumably native African species, although apparently offering a favorable medium to fruit flies, were not found infested; among them were Irvingia barteri Hook. and Blighia sapida.

#### Ceratitidis capitata in West Africa

Assuming that the Mediterranean fruit fly is a native of West Africa, records of its occurrence there are surprisingly meagre. Silvestri took two adults at Olokemeji, Nigeria and records the species from Daberny and the Congo. Cotterell's record from Aburi, Gold Coast, is, as has been stated, the only West African breeding record known to the writer. We did not breed the species from any of the fruits with which we worked. It strikes the writer as probable that if capitata is a native of West Africa, its preferred host fruit will be found to be some obscure and little known native fruit, occurring perhaps not in the coastal region, but in rain forest or savannah country at a fairly high elevation. It is possible that a region similar to that of the highlands about Yeounde in the French Cameroons would be a promising area in which to locate the native host fruit of the Mediterranean fruit fly.

#### Recommendations

Should further work ever be done on fruit flies and their parasites in West Africa the following suggestions, the writer believes, would prove useful:

1. Sierra Leone should be worked from December into late February with the specific objective of procuring adults of Hedylus giffardi Silvestri. Fruits of Chrysophyllum pruniforme, and to a less extent, of Conopharyngia longiflora, are excellent sources of material. Before successful introductions of this braconid can be expected it will be necessary to understand more thoroughly the mating habits of the species. It is possible that the species mates while in flight; releases might successfully be made in large cages over infested host material.

2. In southern Nigeria the most successful working season is apparently December into February or March. In May the fruiting season for winter fruits is definitely over, while it is too early for large numbers of summer-ripening fruits. A promising looking Hedylus-like braconid with a very long ovipositor can be obtained from Dacus brevis-tylus Bezzi (#110) breeding in fruits of Momordica charantia near Ibadan.

3. A wide variety of host material seems probable in the western province of the Gold Coast, and here, as in Sierra Leone and southern Nigeria, the best season would appear to be the early winter months, immediately after the cessation of the rains. The government fruit farm at Asuansi affords good working conditions in a well-wooded area.



4. The most promising of all the regions visited, and at the same time offering advantages of climate unapproached by other West African localities, is the region about Yaounde, the capital of the French Cameroons, located at an elevation of some 2500 feet, about 200 miles east of the Gulf of Guinea. There are numerous roads radiating in all directions from the town, and both rain forest and savannah country are easily accessible. June proved to be a good month in so far as availability of ripe fruits is concerned, but it is possible that other seasons of the year might be equally good or better. Among the more promising braconid parasites of trypetid larvae occurring in the Yaounde district are two apparently distinct *Hedylus*-like species bred from one or more of the following: Carpophthoromyia n. sp., (#127), Ceratitis punctata (#128) and Ceratitis annonae (#130 & 131) in Myrianthus, Conopharyngia and Cola.

The richness of the trypetid fauna observed during a short stay in the Yaounde country makes it seem probable that this is one of the most promising areas in West Africa in which to conduct fruit fly studies.

5. Although very little is known firsthand about the possibilities in the rain forest region of the Belgian Congo, if time allowed, a thorough study of conditions in say, the neighborhood of Leopoldville, might be worthwhile.

6. Until some device is developed for holding parasites at a reasonably low temperature, shipment by air across the desert area of north Africa to Europe is not recommended. Successful transportation of parasites can, at present, be most reasonably expected from shipments which are personally conducted on steamers running direct to the United States. Use can be made of refrigeration (about 45 degrees F.) for parasites issuing enroute, and there is ample room for laboratory facilities of a sort.

7. On a short expedition the most profitable use of time can be effected by sending at least two men together. After material is located two or more personally conducted shipments can be made in fairly rapid succession.

#### Acknowledgments

The Department's West African fruit fly expedition is indebted to the following gentlemen whose advice or help was of the greatest assistance to the carrying out of the project:

Sir Guy A. K. Marshall, of the British Museum; Mr. F. A. Stockdale, Agricultural Adviser to the Colonial Office; Dr. W. R. Thompson, of the parasite laboratory at Farnham Royal, Bucks., England; Mr. J.C.F. Fryer, Director of the Plant Pathological Laboratory, Harpenden, England; Dr. F. J. Martin, Mr. G. G. Auchinleck and Mr. O. T. Faulkner, Directors of Agriculture in Sierra Leone, Gold Coast and Nigeria, respectively; Messrs. Ernest Hargreaves, F. C. Deighton and G. M. Roddan, of the Sierra Leone Department of Agriculture's Njala experimental farm; Mr. C. W. F. Line, of the Gold Coast Department of Agriculture's fruit farm at Asuansi; Mr. W. F. Stevens, mycologist of the same department's Aburi station; Mr. F. D. Golding, entomologist at Moor Plantation; Prof. August Chevalier, of Paris, whose letters of introduction to French colonial officials in the Cameroons and in Equatorial Africa were greatly appreciated; Dr. W. T. Swingle, of Washington, D. C., who gave us letters to Dr. Chevalier; M. Louis Lefevre, the Colonial Secretary at Yaounde, Cameroons; Dr. Mary F. Cushman, of the Protestant Mission at Andulo, Angola, who delivered a package of parasites when the writer was for lack of time unable to proceed to Leopoldville; Mr. John S. Richardson, Jr., American Consul at Leopoldville, who forwarded the shipment by plane; Mr. George V. Richardson, British Vice-Consul at Matadi; Mr. Thomas A. Hickok, American Consul at Lagos, Nigeria; and Mr. J. C. Bridwell, of the U. S. National Museum.

We are also indebted, for shipping facilities, to Capt. C. C. Roberts, agent at Lagos for the American-West African Line; to Mr. C. K. Nielsen and W. H. Robinson, agents at Freetown for the same firm; and to Capt. Walker, Freetown agent for the Elder Dempster Lines.

R. H. Van Zwaluwenburg,  
August 20, 1936.

### Bibliography

- Silvestri, F. - Report of an Expedition to Africa in Search of the Natural Enemies of Fruit Flies. Bull. 3, Div. of Entomology, Territory of Hawaii, Board of Agriculture and Forestry; Honolulu, Hawaii, Feb. 11, 1914, 176 pp., 2 maps, 24 pls. (69 figs.).
- Fullaway, D. T. - Report of the Work of the Insectary, Division of Entomology, in Report of the Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii for the Biennial Period ending December 31st, 1914; Honolulu, T. H., 1915; pp. 146-151.



SUPPLEMENT

By J. M. McGough

This supplementary report covers the period from June 24 to September 23, 1936, during which period I was carrying on independent investigations in the French Cameroons.

Myrianthus - 1,264 fruits bought and 27,150 puparia collected. The fly reared was a Ceratitis and the parasites were blacks and reds (some of each mated) and Tetrastichus.

Cuttifaera - (smaller fruit) A few fruits and puparia obtained. A Ceratitis reared but no parasites.

Cuttifaera - (larger fruit) Over 1,500 fruits obtained and 1,682 puparia collected. The parasites reared were blacks and reds and the fly a Ceratitis.

Gourd - 13 fruits were bought and 1,779 puparia reared. An Opius (?), a Biosteres (?) and a Dacus emerged.

Squash - 5 fruits were bought and 879 puparia collected. A Dacus was reared but no parasites.

Emilis - Marcelia (Anarcadeaceae) - 50 fruits were collected and 69 puparia reared. A Ceratitis and a small Hedylus-like parasite emerged.

Conophyringia - About 827 fruits were bought and 1,060 puparia reared. From these emerged a Ceratitis and a black parasite.

Cola (green) - Approximately 225 fruits were bought and 2,408 puparia reared. From these emerged a Ceratitis, a black with long ovipositor and a red parasite.

Cola digitata - From 90 fruits bought were reared 2,024 puparia. From these emerged a Ceratitis, a Hedylus and a stout reddish parasite with a black head and a very short ovipositor, and Tetrastichus.

Egg Plant - From the one fruit were obtained a few puparia from which emerged a Dacus and a small Hedylus-like parasite.

Cola (brown) - Only 12 pods were obtained and produced a very few puparia from which emerged a single Ceratitis.

"Abam" - 6 fruits were bought and a Ceratitis and a Biosteres and Hedylus were reared out. A total of puparia reared was 29,745. The number of parasites reaching Moorestown, N. J., alive were:

Ex Myrianthus 186 blacks, many mated, 66 reds, some mated;  
Ex Cola digitata 5 reddish blacks unmated; 1 Hedylus unmated;  
and Tetrastichus ex "Abam", 2 females, blacks (1 mated) and 1  
female, red, unmated; ex Cola (green) 7 blacks unmated; ex gourd,  
4 reds unmated.

A cold storage test in a frigidaire of about 32° F. to 36° F., proved that puparia of about six days' age would emerge fairly well, even if left there for sixteen days.



REPORT ON THE UNITED STATES DEPARTMENT OF AGRICULTURE

EAST-AFRICAN FRUIT FLY EXPEDITION OF 1935-36

F. A. Bianchi, Associate Entomologist  
Noel Krauss, Assistant Entomologist  
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INTRODUCTION

The expedition of which an account is here presented was one of four which the United States Department of Agriculture undertook simultaneously during the latter part of 1935. Its object, like that of the other three, was the search for, and if possible the introduction of useful new natural enemies of the Mediterranean fruit fly into the Hawaiian Islands. The range of its activity was to cover East Africa, including all the African lands bordering upon the Indian Ocean, the Gulf of Eden, and the Red Sea, and not necessarily excluding, if time sufficed after such a large order, the African countries along the Mediterranean. The time that was to be dedicated to each country or locality and the route to be followed by the expedition were left to the discretion of the members and to the exigencies of travel. The personnel, as was the case, excepting one person, with the other three fruit fly expeditions, was drawn from the ranks of Hawaiian entomology. It consisted of myself, as Senior member, and of Noel Krauss, as Junior, and our appointments, though in form not differing from those of permanent character, were understood to be temporary and intended to last only one year, or for such a longer period as the completion of the work might require if at the end of a year the prospects of the expedition warranted its continuance.

The organization of the expedition and its work was carried out under the immediate supervision of Mr. C. P. Clausen, Chief of the Division of Foreign Parasite Introduction, Washington, D. C. To him we reported the progress of our work, and through him we cooperated, when necessary, with other branches of the division under his care. The funds, however, for the fruit fly project, of which the East African expedition was only a part, were not drawn from the regular appropriation of the Bureau of Entomology and Plant Quarantine, but from funds allotted to it out of the proceeds derived from the Sugar Processing Tax. Our work, therefore, was in the nature of a temporary and extraordinary undertaking of the Bureau of Entomology and Plant Quarantine. Because of this fact, when, in January 1936, the unconstitutionality of the AAA was established, the Sugar Processing Tax in consequence abolished, and the Bureau left in a very uncertain financial position, our expedition had to be temporarily halted until regular funds became available to carry it on. This occasioned a waste of more than two months of precious time, which we were forced to spend in Tanga, a town conveniently central in regard to several fruit producing areas, but

unfortunately not itself in a locality favorable to the furtherance of our work. In addition, the time we originally counted on was further shortened in the end by at least a month, because of financial stringency not entirely relieved by the new appropriation. Though in the fulfillment of its ultimate aim, the introduction of useful new parasites into Hawaii, our expedition failed completely, mainly because of the short time of its active existence, it cannot yet be classified as a useless enterprise. The field we covered was practically virgin territory from the standpoint of fruit fly research, and it is quite possible that among the abundant material we collected, now properly preserved and in the hands of the Taxonomic Division of the Bureau of Entomology and Plant Quarantine, may appear new species of fruit flies or parasites worthy of attention in the future.

In an earlier report an account has been given of the course of the East African expedition from the time of our leaving Hawaii to the beginning of our enforced vacation in Tanga. The same ground is gone over now with more detail in certain parts, in the hope of enhancing the value of this account for those who may some day be fortunate enough to continue the investigation of our problem in East Africa, a fascinating field which we feel regretfully that we have hardly touched.

#### THE EXPEDITION

Residents of Honolulu, Mr. Krauss and I received our appointments from the United States Government, and orders to proceed to Washington, D. C., in the former city during August 1935. We sailed from Honolulu, together with Mr. Van Zwaluwenburg of the West African expedition, aboard the SS MALOLO, at noon of September 7, 1935; arrived in Washington on September 20, and remained in that city until October 8.

The days spent in the Capital were dedicated to final preparation of the expedition and to further study of technical problems probably to be met. One short trip in particular, from October 2-3, was made in pursuance of this object to the Entomology and Plant Quarantine Laboratory at Moorestown, N. J., where we were shown several methods of rearing, storing, and shipping parasites employed at one time or another by that laboratory. None of these, unfortunately, turned out to be of much use to us in Africa.

Still in the company of Mr. Van Zwaluwenburg, and joined now by Mr. J. M. McGough, also of the West-African expedition, we sailed from New York on the 9th of October on the SS MANHATTAN, and landing at Plymouth, England on October 15, arrived in London on the same day.



A delay, partly due to the necessity of accommodating our itinerary to steamer schedules, was taken advantage of in London to make contacts with a number of British officials and scientists. These included, among others, Sir Guy Marshall, Dr. W. R. Thompson, and Mr. F. A. Stockdale, Agricultural Adviser to the Secretary of State for the colonies. Though little of it was of a specific nature, the advice of these men proved valuable, and the numerous letters of introduction provided by Mr. Stockdale, in particular, never failed to bring all possible help and cooperation our way when presented. In the British Museum, Sir Guy Marshall kindly took us through the entomological collections, but there was little there of use in connection with our problem.

On October 21, parting from Messrs. Van Zwaluwenburg and McGough in London, we crossed the English Channel to France, and stopping one day in Paris, we arrived at Hyeres, Var, on the 24th.

Arrangements were satisfactorily concluded there in consultation with the staff of the European Parasite Laboratory, for the necessary care and forwarding of any parasite material which might be shipped either by the East or the West-African expedition. In the case of the East-African expedition, it was decided that shipments should be either by steamer or by air routes, according to the nature of the material and the place from which it was shipped. If by ship, they were to be addressed to the European Parasite Laboratory directly. If by air line, shipments were to be addressed to Dr. Parker, care of the American Embassy in Paris. In either case, Dr. Parker was to be notified of any shipments as early as possible at his headquarters in Hyeres, and either he or one of his men was to meet the shipment in France, attending to it as necessary and forwarding it to the United States by the earliest or fastest steamer available.

A somewhat different understanding was arrived at in regard to shipments from the West Coast expedition, and of these, as well as of our own arrangements, all persons concerned were informed by means of a circular drawn up and distributed by Dr. Parker.

On October 27 we sailed on the last stretch of our journey to Africa, leaving Marseille on the German-Africa Liner WATUSSI, and arriving in Tanga, Tanganyika, on November 14.

"En route" we touched several ports, including Genoa, Port Said, Port Suez, Aden, and Mombassa, and in three of these, Port Said, Aden, and Mombassa, we spent some time in the native markets in search of fly-infested fruit, but we saw very little fruit in all except the Mombassa market, and found nothing to record.

On the advice of Mr. Stockdale, it had been decided in London that our course in Africa could best begin by a visit to the East African Agricultural Research Station, at Amani, Tanganyika, some 80 K. inland from Tanga, and accordingly we landed in Tanga on November 14, and on the 16th made our first trip to the station. Cordially received by the Director, Mr. W. Nowell, and his staff, we spent that day there, and made arrangements for the early return and accommodation of one of us during a stay of indefinite length.

The East African Agricultural Research Station is an imperial institution, entirely independent administratively from the local government, and supported by direct contributions from all the mandates, colonies, and territories of East Africa. Its object is the conduct of basic research in the problems of East African agriculture, such as is beyond the practical scope of the various Departments of Agriculture. It is in charge of a director and a staff of ten selected scientists, besides a number of assistants, technicians and clerks. With complete shop facilities and plenty of water power it is almost a self-sufficient unit, providing for practically all of its own requirements in the way of power, housing, furniture, apparatus and even food. It has a very good library, several well appointed laboratories, and extensive botanical and entomological collections. The residences of its staff are in all cases modern and attractive.

Beautifully situated about 3,000 feet above sea level, just below the crest of the eastern range of the Usambara Mountains, and surrounded by magnificent gardens and experiment plots, Amani, as the Research Station is usually called, is a place which no visitor to Tanga ever willingly misses. To us, however, in addition to its many other attractions, it offered the main advantage of its location on the very edge of more than a thousand acres of practically virgin forest of the rain-forest type, which we could not have reached anywhere else in Tanganyika without great effort and loss of time.

On November 19, Krauss returned to the station and was immediately established in the comfortable residence of a temporarily absent member of the staff. While he enjoyed the advantages of Amani, I remained in Tanga.

Tanga though only 80 kilometers from Amani is a very different place. It is only about 50 feet above sea level, and though of rather arid soil, is distinctly tropical, both in regard to its torrid climate and the nature of its agriculture. The town itself is surrounded by a mile-wide strip of coconut plantations. Beyond that, in every direction, the Tanga Plain, lying between the Ocean and the Usambaras, is a practically continuous growth of sisal.



In the town itself and its near surroundings a certain number of fruit trees were tolerated, rather than cultivated, by the native population. These included citrus fruits, guavas, many mangoes, an abundance of Termanali cattapa the ubiquitous tropical almond, with which some of the main streets were lined, and a scattering of others, but in only one case did fruit collected within limits of the township yield either Trypetids or parasites. From a Coccinea sp., in this single case, were reared twenty specimens of Tridacus vertebratus Bez. (Ta 1).

As the terminus of the Tanganyika railways, Tanga has a large native population in addition to its two or three hundred whites. Its market, for that reason, draws fruit, among other food products, from a large number of native plantings scattered widely over the interior plains--the Tanga Plains--as they are called. Through the market, therefore, I could ascertain the status of fruit fly conditions over a large area, and I endeavored to do so by making regular and exhaustive visits to the market at least twice weekly during my stay in Tanga.

A more direct approach to the Tanga Plains I obtained by riding trains on the single road that goes inland from Tanga. Using the stations within a range of sixty miles from the terminus as foci I covered the surrounding country on foot. In a country of terrific heat, where native compounds are usually small, poorly cultivated, separated by majestic distances and inhabited by a dull, if not altogether unfriendly people, this task was not always pleasant. In the end it proved completely unremunerative.

By the first of December I had spent two weeks in Tanga. Through strenuous effort I had covered a large territory around it and had a good idea of fruit fly conditions in it. They were not such as to arouse enthusiasm, but the local situation of Tanga in regard to other possible fruit-growing areas and to the lines of communication with them, made it advisable to retain Tanga as central headquarters until we had exhausted all the country accessible from it. Leaving most of my equipment in the Tanga Hotel, therefore, together with about 100 pounds of fruit spread over the sand-covered bottoms of miscellaneous boxes, I journeyed by air on December 3 to the Island Sultanate of Zanzibar. This trip takes a little under an hour by airplane and can be taken with almost absolute regularity every Tuesday. By water it may take as long as 16 hours, and one might often wait two weeks or longer for a steamer.

Zanzibar is a real tropical paradise. It has a thick native population of Swahilis and Arabs, and very little of the island is uncultivated. As the exportation of copra and cloves is the main industry, practically all the land is given to coco palms and clove trees, but I could see even during the short run from the landing

field to my hotel that fruit would be abundant. A visit on the afternoon of my arrival, to the magnificently stocked market proved my earlier observation to be correct. The variety of tropical fruits and vegetables to be had there far exceeds that of any other tropical market I have seen. Unfortunately very few of the species were infested by fly and of these the number of fruits with grubs in them was small. The only government land given entirely to fruit is a small but very well kept plot of introduced citrus trees. I saw there about one hundred healthy trees comprising some twenty different varieties, but none of the fruit showed even signs of being stung by fruit fly. That same afternoon I bought my first lot of fruit and placed it over a layer of sand in a number of Haigs whiskey boxes.

The next days I spent either in the immediate surroundings of the city, on foot, or farther afield in a motor car. On some of the longer expeditions I enjoyed the advantage of being guided by Mr. Squire, Superintendent of Government owned plantations. Mr. A. J. Findlay, in charge of the Department of Agriculture, and to whom I had a letter of introduction from Mr. Stockdale, was at the time of my visit very busy, but by placing me in Mr. Squire's care he satisfied all my needs. In the company of this gentleman I had free access and transportation to all the Government plantations and experiment plots. Though of these only one was dedicated to fruit growing, it was always possible to find, either in them or along the roads to them, the small native plantings which supply the market.

Twenty-two miles from the city of Zanzibar, near a village called Peete, there is a wooded area covering 2-1/4 square miles. It is called Jozani Forest and is supposed to be the last remnant of the growth of native trees which originally covered all the land. In the hope of finding some native fruit or berry that might harbor indigenous fruit fly parasites, I spent a whole day in these woods. I found, however, nothing of interest, and collected only two species of fruit which might be fly hosts. One of these, an oil palm which my guide did not consider indigenous, constituted one of the predominant species in Jozani Forest. The other, very scarce, was a Spondias sp., which I could not identify.

The variety of fruit grown in small quantities in Zanzibar is enormous. Among the fruits to be found either in the market or in native plantings, the species I knew or was able to have identified included the following: Many varieties of bananas, ranging in size from 3 inches to more than 2 feet; some twenty or more varieties of citrus; coconuts; pineapples; many varieties of mangoes (some of those in the market are imported from India, not island grown); guavas and strawberry guavas; a small yellow Spondias sp.; cashew; granadillos of at least two species; pomegranate; roseapple; several kinds of avocados; papaya; cacao; coffee; tropical almond; mangosteens; duriano; mulberries; anonaceae of various species; chrysophillum; mamey; sapota (*Achres sapota*); Jack fruit; bread fruit; Averhoas, of at least two species, and perhaps others which escaped my attention.



In addition to the fruit there was a considerable selection of vegetables, mostly in demand by the East Indian section of the population, some of which may well be hosts of the fruit fly. These included mostly members of the Cucurbitaceae which I had never seen, but which I examined carefully in every case and in one or two cases found infested by Dacus.

By the end of ten days I had visited practically every corner of Zanzibar and had examined a fair selection of the fruit available at the time. All of this which was, or seemed, infested by fly I had collected and laid out properly over clean sand. As it would take several days for either parasites or grubs to reach maturity in the fruit, I decided to store it and to return once more to Tanga to examine the material which I had previously left there. Accordingly, on December 12 I sailed on the small intercoastal steamer DUMRA and arrived in Tanga on the next day, leaving in storage in Zanzibar fourteen boxes each partly filled with fruit laid over a thin layer of sand.

Upon my return to Tanga I found Krauss back from Amani. Because he felt that place had been sufficiently well surveyed, and because his temporary residence was being demanded for other visitors, he had left Amani on December 12.

His report of our prospects in that area were not very encouraging. A large variety of cultivated fruit trees are found in Amani, but these are at no time very numerous, and many were not yet in fruit. The same was true of indigenous forest varieties. However, Krauss had either reared or seen fruit flies from Kueme Nut, coffee (of which at the time there were only a few prematurely ripe berries), roseapple and orange, among cultivated fruits, and from Sersalisia usumbarensis among the fruits indigenous to the forest. This last fruit, Sersalisia usumbarensis Eng., is of the Sapotaceous family and is, as its name implies, indigenous to the usambaras. Most of the trees we saw were only medium sized, but they sometimes reach 20 or 30 yards in height and may produce a correspondingly large amount of the fruit, which is about the size of a large olive and is borne in great quantity by each tree.

When completely ripe the fruit falls to the ground by itself or is easily shaken off by birds and monkeys, and from ground-collected fruit Mr. Krauss had bred two different species of Ceratitis punctata Wied (Aml) and C. colae Silv. (Am2), obtaining from these flies two kinds of parasites (Amla) Tetrastichus dacicida Silv., a Chalcid, and (Amlb) Opius perproximus Silv., an Opiine.

Three or four living adults of each species of parasite, a small quantity of *Sersalisia* fruit and about 200 possibly parasitized fly pupae represented all the material available at the time of Krauss' departure from Amani, but on December 17 we motored again to the Experiment Station, and spending the whole day there, obtained about 20 pounds more of the fruit and about fifty more of the buried fly pupae.

The Amani forest is in most places too densely covered with undergrowth, and the slope of its ground is in most places too steep to permit an exhaustive search within the forest for any particular tree. For that reason we depended for our supply of *Sersalisia* on trees near to the roads which cross the forest in several directions. These trees numbered no more than a dozen, within knowledge of the guide kindly provided us by Mr. Nowell, and though many of these were large and bearing heavily we were handicapped in obtaining their fruit because of the fact that it constitutes a favorite food of one of the commonest birds of the region, the fantastic horn-bill.

Later we were able to obtain, through the courtesy of the Experiment Station, 250 more pounds of *Sersalisia* fruit. But either because this fruit had been shaken prematurely off the trees, or for some other unknown reason, this large lot eventually produced not many more parasites than had been obtained out of the small lots we ourselves collected.

With this shipment the 1935-36 crop of *Sersalisia* was exhausted.

On December 18, taking advantage of one of the rather irregular sailings to Zanzibar, Mr. Krauss journeyed to that island on the SS MAIDA. The object of his visit was to examine the fruit I had previously collected and, if the time of his return sailing permitted, to continue my collections and observations. In the fulfillment of both aims he was generously aided, as I had been, and on January 5 he returned to Tanga.

During his stay in Zanzibar Mr. Krauss reared from his material and mine, Carpolonychaea plumosissima Bez., Ceratitis capitata Wd. and C. colae Silv., (Z1) from guava, a small black Trypetid Ceratitis n. sp. (Z2) from a *Psychotria* sp. (a small red berry from a vine called Anyoina by natives, and Tridacus pectoralis Wlk. (Z3, Z4, Z5, Z6) and Dacus brevistylus Bez. (Z5) from Luffa egyptica, Momordica charantia, pumpkin (undetermined species), and cucumber. A few specimens of Dacus were also reared from an unusual yellow cucurbit which was bought in the market and not identified.



Parasites emerged from pupae of this material, either while Mr. Krauss was still in Zanzibar, or later, when the pupae had been brought to Tanga, as follows: From Momordica charantia, one specimen of a Dirhinus n. sp. (Z4a); from cucumber, one specimen of Spalangia afra Silv. (Z6a); from pumpkin, one specimen of Opius perproximus Silv. (Z5a); and 16 specimens of Spalangia ofra Silv. (Z5b); from the Psychotria berries, 4 specimens of Opius n. sp. (Z2a); and one of Spalangia afra Silv. (Z2b).

We could judge by now that in Zanzibar, Dacus, of one or another species, was common and was attacked by several parasites. On the other hand, Ceratitis was very scarce, and we had no evidence of its being parasitized by anything. Quite probably it is parasitized by some of the very parasites we had already bred from Dacus, but this we knew would take time to prove, and as the parasites on hand were not especially promising, we feared that the knowledge once acquired might prove useless. We decided, therefore, to concentrate our efforts on the Ceratitis and parasites we knew existed in Amani.

This course itself, with the material on hand, offered no very brilliant prospects, but we decided to start in the small way that circumstances permitted, hoping to do better as we went along.

A very thin stream of parasites had been emerging during ten or twelve days from Sersalisia fruits, and though some had died and some had escaped, because of our crude facilities for handling them, on January 9 their total number amounted to 13 females and 13 males. Of these consisted our first shipment, which in agreement with previous understanding was made via aerial parcel post to Dr. Parker, in care of the American Embassy in Paris. Waiting until the last minute to be able to include as many newly emerged individuals as possible, the Opiines were placed in a shipping cage patterned after a sample of a large oriental fruit moth cage which we had in our possession, and they were then rushed to the post office. Dr. Parker was at the same time informed by cable of their probable arrival and departure from Cairo on January 20. But it would have been as well not to have rushed. The valued products of our labor were destined not to reach even the first leg of their journey to Hawaii.

On January 22, a cable informed us that Mr. Smith, of the European laboratory, had failed to find the shipment in Paris. On January 31, a second cable informed us that the package of insects had at last appeared but that all the parasites, as well as all those contained in a second shipment we had made from Tanga on January 22, had arrived dead.

We eventually learned, after much correspondence and inquiry, that one cause of our failure had been misinformation conveyed to us by postal clerks as to the route that air parcel post follows from Tanga to Paris. We had been told our packages would go by air on the same day to Nairobi; that within a few hours they would leave Nairobi and reach Cairo three days, at the latest, after Tanga; that at Cairo they would be transferred to another airline and taken within a day of arrival to Brindisi, Italy, and at Brindisi they would be placed on a through train, arriving in Paris within 48 hours. The actual facts were different. Air parcel post or first class air mail, unless specific instructions are given and a higher rate of postage paid, is handled from Tanga to Nairobi by train like ordinary mail, taking for this stage of the journey sometimes as much as four days. They are placed on a plane at Nairobi (if the train arrives after the plane's departure, a common occurrence, it may imply an added delay of one week). They are not transshipped at Cairo or Brindisi, but flown in the same machine to London, and from London to Paris they travel again as ordinary mail.

Air freight, we were told, handled directly by the airline people would follow a more direct course from Tanga. It would be flown to Nairobi, transshipped there, placed on a train at Brindisi, and forwarded thence within 48 hours to Paris. We employed this means for a third and last shipment of the Sersalisia parasites. Because of low percentage of parasitism, even the large quantity of fruit we had by now on hand failed to make this third lot larger than the first two. It consisted only of 20 females and 6 males and left Tanga in the same type of container as the first two, on February 13. It took ten days enroute to Paris, arriving there on February 23, and only five individuals--females--arrived alive. The package had evidently received treatment not suitable to its fragile nature, and the water bottle, though tied in place by means of wire and stout cord, had shaken loose and killed a number of the insects. Others had died of natural causes. Only four females eventually arrived in New York. They were not considered worth shipping on to Honolulu, and eventually found an end to their precarious existence in the Moorestown Parasite Laboratory.

We were at this stage of our enterprise in Africa, just getting our first taste of the difficulties the work involved, when a greater and unexpected difficulty arose in another quarter.

The AAA had been found unconstitutional and all expenses being made under its aegis were to stop immediately. We were informed of the fact by cable of January 10, even before the last two of our three shipments were on their way, and from that date we remained in Tanga in enforced and irksome inactivity until February 21. A second cable from Washington on that date suggested an early and satisfactory adjustment of our financial difficulties and urged the preparation of as large a shipment of parasites as possible, to be personally conducted by one of us to America when funds should eventually become available for our return.



That suited our impatience well, and although our hopes of securing any large quantity of parasites in Tanga were small, we renewed our efforts in that direction.

Of fruit fly conditions in the more or less immediate vicinity of Tanga it had not been difficult to keep ourselves informed during the period of curtailed expenses, but of conditions in the more remote areas, not accessible on foot, we knew nothing, and we thought them worth investigating. It was not possible to obtain transportation until the 25th, but on that date we journeyed to Amboni and Sigi-Sigoma. At Amboni, a sisal plantation about five miles northwest of Tanga, we had ascertained during an earlier visit on foot the presence of a large grove of guavas. This covered several acres and was the only place in Africa where I ever found guavas growing in abundance comparable to that of other tropical countries. The crop was beginning to ripen and we gathered about 30 pounds of fruit, from which no flies were reared.

At Sigi-Sigoma, a German-owned and German-run plantation of several thousand acres some 40 miles from Tanga, at the base of the extreme north end of the West Usambaras, we found a great many varieties of tropical and semi-tropical fruits under cultivation, including guavas, loquats, several kinds of citrus, several kinds of bananas, coffee, cacao, pineapple, pepper, cinnamon, and many others. In quantity, however, we were able to collect only luffa and guavas. From the guavas we reared several dozen specimens of Ceratitidis colae Silv. (Ss1), and from luffa Tridacus pectoralis Wlk. and C. punctatifrons Karsch. (Ss2). From the other fruit, nothing.

Finding nothing useful in the new areas, and hoping that satisfactory developments had taken place in Amani during our absence, I returned to that vicinity and spent the 26th, 27th and 28th of February in a small hostel, Nderema, about a mile from the Experiment Station and actually within the Amani Forest. A considerable variety of forest and cultivated fruits was again available, but as was the case during Mr. Krauss' visit, very few could be found in quantity. Sersalisia usumbarensis, the useful fruit fly host, earlier available by the sackfull, was out of season. Several trees of guava were fruiting and also about 100 trees of strawberry guavas, and from these were collected some forty pounds of the common guavas and some twenty pounds of the strawberry variety. The rest of the collection included twenty-five specimens of Myrianthus arboreus P. Beauv., four pounds of Drypetes battiscombei Hitch., two pounds of a small native fruit hitherto classified as Rauwolfia but now found not to belong to that genus.

During a second visit to the Amani area I remained in Nderema from March 15 to the 18th, securing then further limited quantities of the fruits mentioned above, and adding several dozen specimens of Dioacorea macrura Harms and of Peponium usumbarensis Eng., and one dozen snake gourds, Coccinia engleri Cogn. A large quantity of a pulpy, yellow, leguminose fruit, Cordyla africana Lour., was also collected at this time, but nearer to Muheza than to Amani.

Among this fruit collected during the last two visits to Amani, the incidence of fly was great only in the case of strawberry guavas. From our twenty or thirty pounds of this fruit we reared a very large number of (Am3) Ceratitis capitata Wd. and C. colae Silv. Some of the other fruits, however, though in lesser degree, were also infested as follows: Myrianthus arboreus by (Am4), Ceratitis rubivora Coq., and C. colae Silv., Drypetes bettiscoabei by (Am5), C. colae Silv., Cordyla africana by (Am6), C. cosyra Wlk., Dioscorea macrura by (Am7), Tridacus pectoralis Wlk., and common guava by (Am8), Ceratitis colae Wlk.

Parasites were reared only from Cordyla africana. Roughly, 20 percent of our material was parasitized by (Am6a) Opius perproximus Silv. Unfortunately no more of this fruit was available than we had already collected, and the total number of parasites obtained totaled only twenty or thirty specimens.

Already before the period of curtailed expenses, I had spent two week ends in the East Usambares in the region generally called "Lushoto" and though I had found the beautiful elevated plateau interesting and very pleasant in contrast to the torrid Tanga Plains, I had been unable to find there enough fruit material to warrant a second visit. Peaches were the single fruit I had obtained. From about 40 pounds of fruit showing almost 100 percent of fly incidence I had reared Ceratitis colae Silv. (Lul), but of native fruits I had seen none, and of other cultivated ones very few. Several temperate zone fruits are said to be cultivated to some extent in this region, and one sometimes finds small quantities of rather good fruit of this kind in the Tanga market, but during my stay in Lushoto (November 30 to December 1, 1935 and December 24 to 26) I was able to find only scattered trees of peach, plum and apricot, of which only the peaches were then bearing.

Repeated visits to the fruit growing areas accessible from Tanga and continuous trials of the fruit obtained therein, had convinced us that our chances of obtaining in this field enough parasite material for shipment were very small. It would even be almost impossible, we believed, to breed any great number of parasites in the laboratory. Both the parasites and the suitable infested fruit we had so far found were too scarce for breeding work in the laboratory. We were delighted, therefore, when the injunction against our spending money for travel was finally removed. We learned of the fact through a cable received in Tanga on March 16 while I was in Amani.



Deciding that we should carry our investigations farther into the hinterland of Tanganyika, I left Tanga by rail on March 20, with Arusha as my first destination.

Krauss, with the slight hope in mind of obtaining one last shipment of parasites from Tanga, remained behind me two weeks longer in charge of our lately collected fruit from Sigoma, Amani and Amboni. On April 5 this last hope had died and Krauss left Tanga for Nairobi, spending on his way one day with me in Arusha, and arriving in Nairobi, the Capital of Kenya Colony, on April 7.

For reasons which appear later in the course of this report, the early promise of Nairobi was not fulfilled. It struck us from the beginning, however, as the most favorable location within our knowledge of East Africa for the work we were conducting. With a population of about 50,000 inhabitants, of whom some 6,000 are Europeans, the city is the most important in East Africa, and as such is within three or four days communication with Europe via the Imperial Airways, and is also the center of a large and fertile territory fairly well covered by road and rail. In addition, it was particularly desirable to us as a location because it provided within its own city limits, or within easily negotiable distance of them, a rich supply of both native and introduced fruits.

Registering at the "Norfolk", one of many good hotels in Nairobi, because the location of this hotel near the edge of the city gave him easy access to the surrounding country, Mr. Krauss set up an improvised laboratory in a portion of a large porch, and from the day of his arrival, April 7, began the collection of fruit.

Through members of the Kenya Forestry Department, particularly Mr. H. M. Gardner, he soon became known and never experienced any difficulty in securing any fruit he wanted from the city's fruit producing areas. These included a very well kept arboretum of 75 acres extent, rich in minor varieties of native fruit, a privately owned nursery, Graham Bells Nursery, the grounds of several public buildings, principally those of Government House, the tree planted borders of several streets, and one or two public parks. In addition, there were outside of the city, but within an hours ride of it, two fairly extensive wooded areas, the "Ngong Forest" and the "Karura Forest", of which the last provided not only the largest variety but also the largest quantity of native fruit that we had seen anywhere in Africa. There was also a large and modern market, which, in addition to most tropical ones, stocked several Temperate Zone fruits from the Kenya Highlands.

In keeping our fruit in the laboratory in Tanga and in Zanzibar, it had been our procedure to place it over a layer of sand in boxes lined with heavy paper. We used for this purpose mostly whiskey boxes, which in both places were available very cheaply, often free. In Nairobi Mr. Krauss found it more advantageous to use baskets of native manufacture. These were of several sizes, varying from one to three bushels, and both in size and shape, which was that of an inverted cone truncated, filled our needs very well, provided care was taken to line their sides and bottoms thoroughly with heavy paper. They offered the advantages of occupying less space and of being far more easily portable than boxes.

Though parasites did not appear immediately, the great abundance of fruit, some varieties of which were still immature, made prospects bright in Nairobi. It seemed advisable, nevertheless, to explore as much territory as possible while time was available, and with that idea Mr. Krauss made two visits by rail to areas rather distant and different from Nairobi. On the first of these visits, from April 29 to May 5, he collected fruits at Nanyuki, the forested areas near Meru, and the northern slopes of Mt. Kenya. On the second, from May 14 to May 22, he made stops of a day or more at Kakamega, Kisumu and Londiani. On both, he found and examined a very large variety of fruits, some of which he brought back to the Nairobi laboratory, but some of the fruits collected were infested with fruit flies and though eventually produced parasites, none of the fruit was seen in sufficient amount anywhere to warrant a return after more, at least not until Nairobi's promise should prove vain.

In table Number 1 are shown in condensed form the names of the fruits collected during these two trips, the locality of their collection, and the fruit flies and parasites reared from them, if any.

Table Number 2 shows the same data for the more important fruits collected by Mr. Krauss in Nairobi.



Table No. 1 - Material Obtained on Two Field Trips by Mr. Krauss.

Date.	Locality	Fruit Host	Fly Host	Parasite
3/2	Forest near Meru	Doryalis abyssinica	None	None
3/2	" " "	Xymalos monospora		
		Baill	"	"
3/2	" " "	Solanum sp.	"	"
3/2	" " "	Solanum naumannii	KR15 Cera-	
			titis n.sp.	KR15a
3/2	" " "	Kigelia moosa		
		Spreague	None	None
3/2	" " "	Piper sp.	"	"
			C.rubivora:	
			Coq.:	
5/3	Meru, Kenya	Himalayan blackberry:	KR16 C.	KR16a Opius sp.
			colae Silv.	KR16b O.fulla-
				wayi Silv.
5/11	Nanyuki, Kenya	Coffee	KR17	None
5/3,	" "	Pittosporum sp.	None	"
4/29	" "			
5/3	" "	Grewia sp.	"	"
5/3	" "	Todalia asiatica	"	"
		Lam.		
5/4	Northern slope of	Olenia usumbarensis	"	"
	Mt. Kenya	Gilg.		
5/4	" "	Podocarpus milanjan-	"	"
		nus		
4/29	and Nanyuki			
5/16	Kakemega, Kenya	Peponium sp.	"	"
5/16	" "	Solanum, prob. indi-	KR18	O.fullawayi
		cum	Ceratitidis	Silv. KR18a &
			n. sp.	Kr18b Opius sp.
5/16,18	Kagamega, Lond-	Melothria sp.	KR19 Tri-	None
	iani		dacus n.sp.:	
5/16	Kagamega,	Rubus sp.	Kr30, C.	
			rubivora Coq:	"
5/18	Londiani, Kenya	Cucurbit sp.	C. "	"
5/18	" "	Pygeum africanum	"	"
5/18	" "	Passiflora sp.	"	"

5/20	:	Londiani, Kenya	:	Todalia asiatica	:	C. rubivora	:	None
	:		:		:	Coq.	:	
5/20	:	" "	:	Clea hochstetteri	:	"	:	"
	:		:		:		:	
5/20	:	Nanyuki, Kenya	:	Cissus nananquensis	:	Trypetid	:	"
	:		:		:	host	:	
5/20	:	" "	:	Solanum naumanni	:	None	:	"
	:		:		:		:	
5/21	:	" "	:	Allophyllus sp.	:		:	



Table #2. - Material Obtained in or near Nairobi, Kenya by Mr. Krauss.

Fruit Host	Locality	Dates	Fly Host	Parasite
Acokenthera longiflora Stapf.	Arboretum, Ngong Forest	Apr. 7, 8, 11, 23, May 11, 25	Kr 3	Kr3a, Kr3b O. humilis Silv.
			C. capitata	O. perproximus Silv.
			Wd. C. breinii	T. giffardianus Silv.
			Guer-man.	C. cosyra Wlk.
			C. cosyra Wlk.	
Loquat	Arboretum, Govt. House Grounds	Apr. 7, 8, 23	C. capitata Wd.	
	Graham Bells Nursery		C. colae Silv.	
			Kr 1	
Tacsonia sp.	Graham Bells Nursery Arboretum	Apr. 8	Kr 14	
			C. capitata Wd.	
Duranta plumieri Jacq.	Graham Karura Forest Arboretum	Apr. 7, 8, May 11, June 8	Kr 9	Kr9a, Kr9b modestor Silv. O. perproximus,
			Tridacus n.	O. fullawayi Silv.
			sp.	
Ficus mallatocarpa Warb.	Graham Arboretum	Apr. 7, 8		
Doryalis caffra Warb.	Graham Arboretum	Apr. 7, 8, 23	Kr 2 C. cap- itata Wd.	K2a near Halticoptera
			C. colae Silv.	
Carissa edulis Vahl.	Graham Arboretum	Apr. 7, 8, 23		
Podocarpus gracilior Pilger	Graham Arboretum	Apr. 7, 8, May 25	C. colae Silv.	
			Kr 21	
Warburgia ugandensis Sprague	Graham Karura Forest	Apr. 7, 8, June 10	C. cosyra Wlk.	O. perproximus Silv.
			Kr 13	Kr 13a
Randia sp.	Graham Karura Forest	Apr. 7		
Phytolaoa dioica	Graham Arboretum	Apr. 7, 8		
Rawosonia usumbarensis K. Schum	Karura Forest, Arboretum	Apr. 8, June 6, June 8	C. rubivora	
			Coq. C. colae	
			Silv. Kr 26	
Solanum naumannii	Karura Forest, Ngong Forest	Apr. 8 & 23, May	Ceratitis n.	Tetrastichus? xyurus
		11, 25, June 8	sp. Kr 6	Silv. Kr 6a
Solanum campylacanthum Hechst.	Karura Forest,	Apr. 8		

Table #2 - continued

Tecles trichocarpa Engl.	: Karura Forest, Ngong Forest	: Apr. 8 and 23, : May 11	: C. capitata : Wd. Kr 7	: Kr 7a O. fullawayi : Silv. O. humilis Silv.
Vanqueria sp.	: Karura Forest, Ngong Forest	: Apr. 8, May 11	: C. capitata : Wd. Kr 8	:
Olea chrysophylla Lam.	: Karura Forest,	: Apr. 8	:	:
Gardenia urcelliformis Schweinf	: Karura Forest	: Apr. 8	:	:
Ochna sp.	: Karura Forest	: Apr. 8	:	:
Croton megalocarpon Hutch.	: Karura Forest	: Apr. 8	:	:
Orange	: Graham Bells Nursery	: Apr. 8	:	:
Tangerine	: Graham Bells Nursery	: Apr. 8	:	:
Strawberry guava	: Graham Bells Nursery, Karura : Forest	: Apr. 8, 10	:	:
Eugenia australis	: Graham Bells Nursery	: Apr. 8	:	:
Plum	: Market - Grown at Limuru	: Apr. 14	:	:
Apple	: Market - Grown at Limuru	: Apr. 14	:	:
Cucumber	: Market	: Apr. 14	:	:
Fig	: Market	: Apr. 14	:	:
Acoka nthera Schimper Schweinf	: Ngong Forest	: Apr. 15	: C. breinii Guer-Mon : Kr 4	:
Peach	: Government House Grounds	: Apr. 23	:	:
Doryalis macrocalyx	: Arboretum	: May 11, 25	:	:
Clerodendrom myricoides R. Br.	: Arboretum	: May 11	:	:
Bruces antidysenterica Miller	: Arboretum	: May 11, 25, 27, : June 5	: Ceratitidis n. : Opius sp. O. fullawayi : sp. C. capi- : Silv. Kr12a, Kr 12b : tata Wd. Kr12:	:
Cestrum aurantiacum Lindl.	: Arboretum	: May 11, 25	:	:
Cotoneaster pennosa French	: Arboretum	: May 11	:	:
Vitex kenieasis Turrill	: Arboretum	: May 11	:	:



Table #2 continued

<i>Berberis holstii</i>	: Arboretum	: May 11,	: C. capitata Wd. Kr 10
<i>Psychotria nairobensis</i> Brem.	: Arboretum	: May 25	:
<i>Prunus pudum</i>	: Arboretum	: May 25	:
<i>Strichnos</i> sp.	: City Park and many other parts: : of city	: May 25, 26, 30, : June 2, 11, 13, : 14, 15, 20, 22	: Kr 22a, 22b, 22c, 22d, : Opius sp. O. fulla- : wayi Silv. O. perprox : imus nodestor Silv. : Tetrastichus n. sp. : T. giffardianus Silv. : Microbracon celer var.
<i>Tecles viridis</i> Verdoora	: Arboretum	: May 25	:
<i>Elaeodendron</i> sp.	: Arboretum, Karura Forest Cath- : olic School grounds	: May 25, June 8	:
<i>Cissanpelos pareria</i> Linn.	: Karura Forest	: May 25, 26	:
<i>Momordica</i> sp.	: Karura Forest	: May 25, June 8	: Tridacus punc- : tata Frons
<i>Pepcunia cucullata</i>	: Karura Forest	: May 25, 26 : June 8	: Karsch Kr 23 : Kr 24
<i>Deinbollia</i> sp.	: Karura Forest	: May 26	: C. rubivora : Opius sp. : Coq. Kr 25 : Kr 25a
<i>Solanum auriculifera</i>	: Arboretum	: May 27	:
<i>Feifoa sellowiana</i> Berg	: Arboretum	: May 27	:
<i>Hymalayan blackberry</i>	: Arboretum	: May 27, May 5	: C. rubivora : Kr 5a : Coq. Kr 5
<i>Phyllanthus discoides</i> Muell. Arg.	: Arboretum	: June 5	:
<i>Melia azedarach</i>	: Arboretum	: June 5	:
<i>Asparagus</i>	: Arboretum	: June 5	:
<i>Englerodaphne</i> sp.	: Karura Forest	: June 8	:
<i>Cissus mananquensis</i>	: Karura Forest	: June 8	:
<i>Ficus hockstetteri</i> A. Rich.	: City Park	: June 9	:
<i>Dracaena fragrans</i> Gawl.	: Limuru Road	: June 10	:

Table #2. continued

Custard apple	: Government House Grounds	: April 23	:	:	:
Coffee	: Scott Agricultural Laboratory	: June 8	: C. capitata Wd.	: O. humilis Silv.	:
	:	:	: Kr 11	: Kr 11a	:
Dates	: Scott Agricultural Laboratory	: June 8	:	:	:
	:	:	:	:	:
Melothrie sp.	: City Park	: June 9	: Kr 27	:	:
	:	:	:	:	:



Having left Tanga on the evening of March 20, I arrived early next morning in Moshi, a small white settlement about 850 meters above sea level, on the base of the great Kilimanjaro Volcano and the edge of a vast coffee growing plain. As the leisurely time table of my train gave me the opportunity, I spent the morning exploring the vicinity of the town as far as I could do so on foot. Coffee was unripe at the time, and with the exception of about a dozen green guavas in about as many scattered trees I saw only one other potential host of fruit fly. This was a medium sized, rather solid Anonae with yellowish pulp. As none of the fruits seemed infested I did not collect any.

About eight miles out of Moshi, on the road to Arusha, I passed a large and important coffee research station where the late Mr. Ritchie, Tanganyika Government entomologist, had done much of his work. But there was no entomologist here now and I made no effort to visit the place.

My first impression on arrival in Arusha was one of disappointment. The coffee season, which I had been led to believe might be starting at this time, was many weeks away. I learned now that coffee would not begin to ripen until about the first of June, and that the peak of production would not be reached until the middle of July.

Other cultivated fruits were also scarce in the township proper, but I soon discovered several places within reasonable distance of the town where a good many varieties could be gotten. To these places, and to the great extent of uncultivated ground around Arusha, including brush-land and the magnificent forested slopes of Mount Meru, I dedicated three weeks, but in the end my efforts were as unproductive as earlier ones in Tanga had been.

All of the cultivated fruit I gathered while in Arusha came from large coffee estates. Among these "Engare Sero", Vickers Coffee Estates, and the estate of Mr. Van Jaarvelt, all within fifteen miles of the town, provided the largest amount. Their contributions included guavas, oranges and tangerines, quinces and blackberries, but at a different season it might have covered a much longer range, as I also saw many loquat trees, peach trees, plum trees and a few apples.

The contribution of the uncultivated area was less varied. It included only one species to be found in any quantity, a semi-edible *Peponium* species whose vines form large thickets near the town, and from which fruit I reared hundreds of *Tridacus pectoralis* Wlk., *T. punctatifrons* Karsch. and *Dacus eclipsis* Bez. (Arul), but never any parasites.

From another Cucurbit, a large vine with small top-shaped fruit, were reared, in one of the two occasions on which the fruit was found, a quantity of *Tridacus humeralis* Bez. (Aru2), a dozen Braconids, *Opius* sp. (Aru2a), and two specimens of a Chalcid, *Tetrastichus giffardi* Silv.

(Aru2b). As the incidence of fly in this fruit was high and the parasitism fairly so, it was regrettable that not more than two vines of the plant could be found in all the area explored near Arusha. One of the vines, curiously, was found in the plains near the town; the other in the thickest part of Meru Forest, half way up the volcano of the same name and more than ten miles from Arusha. It was in the later instance only that the fruit was found attacked by fly.

Other flies reared in Arusha during this trip were the following: From oranges, C. colae Silv. (Aru3); from blackberries, C. rubivora Coq. (Aru4); from peaches, C. rubivora Coq. and C. colae Silv. (Aru5); from strawberry guavas, C. capitata Wd. (Aru6); from conion guava, C. colae Silv. (Aru13).

Of parasites only one species was reared, Opius giffardi (Silv.) (Aru6a). Ten pounds of the fruit host, strawberry guavas, with an estimated 80 percent of fly incidence yielded eight parasites.

It is worth noting that this was the only instance in which we found parasitism of fruit fly in a host fruit not native to Africa.

is that

The reason of my stay in Arusha, March and April are the spring-time of that region. Beginning in May and lasting through June and July, the weather is apt to be disagreeably cold and continuously drizzly, but during late March it was perfect. In that weather the beauty and great natural interest of Arusha, enhanced by its location at the foot of Mt. Meru, in the center of large game reserves, strongly tempted me to remain longer. But the weeks were slipping by rapidly and nothing had yet been done. I left Arusha by motor car on April 13, and arrived in Nairobi that same evening. Mr. Krauss had been working already several days in Nairobi. He had accumulated a greater variety and larger quantity of native fruit than we had ever seen elsewhere, and was enthusiastic about the prospects. No parasites had yet appeared, however, and as it was possible that eventually none might appear, and thus the efforts of both of us go to waste, I decided to push my exploratory work on to Uganda.

Forced to do so by the railroad schedule, I spent one week in Nairobi at this time. I helped Mr. Krauss collect fruit in Ngong Forest, spent some time in the city's arboretum, met Dr. Van Someren, Curator of the Coryndon Museum, made good use of that institution's large and orderly insect collection, unfortunately very scantily supplied with fruit flies, their enemies or allies, studied in the Museum's very good scientific library, was caught in the rain practically every time I went out of the hotel, and left Nairobi on April 20.



My first stop in Uganda was Kampala. A pleasant town, well laid out on a series of adjacent hillocks, this place with two good hotels and a large bazaar, is often called the Capital of Uganda, but the administrative Capital is Entebbe, artistically situated on the west margin of Lake Victoria, twenty miles away. To Entebbe I journeyed on the next day by car, as with the exception of native busses never employed by Europeans, there is no other method of transport between the two towns, despite their importance.

In Entebbe I wished to make contact with Mr. Tothill, Director of Agriculture, to whom I had a letter of recommendation from Mr. Stockdale. He unfortunately was not at his post during the time of my visit, but in his place I was cordially received by Mr. N. V. Brasnett, Conservator of forests. Through this gentleman's advice, corroborated by my own subsequent observations, and through his kindness in making it possible, my course in Uganda took a very different turn than I had foreseen.

By misinformed people, as far back as Arusha, I had been led to believe that the well cultivated native holdings and the extensive forested areas in the Entebbe-Kampala region would yield a large supply of fruit, but I soon found it was not so. During four days I spent in Kampala, I was unable to collect more than a dozen native fruits, and saw, planted and kept by Europeans, only one planting of loquats. This comprised about ten trees, on which there was very little fruit, and that not stung by fruit fly. The market was poor in fruit and supplied almost exclusively from far distant sources. The forest areas, not a great deal more valuable, as I was told, as sources of good timber than of fruit, were copses of from a few to many acres, always situated along the margins of streams, lakes or marshes. Apart from single specimens of others not worth the trouble of having them identified, I found in the forest only one fruit in any abundance. It was Ficus verruculosa Warb., a small fig of swampy habitat. Guavas were not uncommon here and there in uncultivated areas, but I didn't find them infested by fruit fly. A species of Mimusops planted for shade along roads was common and fruiting abundantly, but it was also not attacked by fly.

Mr. Hargreaves and Mr. Jones, Government entomologists, by whom I was offered the use of laboratory space and facilities in the Agricultural Laboratories at Kampala, corroborated my findings. Seldom had they been able to rear flies, they said, and never any parasites. Their collections, though valuable in other respects, were useless for my work.

During our interview of April 22, Mr. Brasnett had foretold my failure to find fruit flies in Kampala or Entebbe, and had strongly advised me to seek a more probable success elsewhere. On April 24, he very kindly informed me by telephone that he had succeeded in making arrangements for me to stay an indefinite time with one of his men

at the Busingiro Forest Station in the northern province. Thankful for the opportunity to exchange a location, certainly poor, for one probably rich, I left Kampala on April 25 and arrived in Busingiro four days later, on the 29th.

This trip provided a typical example of the difficulties and the waste of time that travelling in Africa still involves. The distance by road between Kampala and Busingiro is only about 200 miles, and by automobile would have taken only one day or less. By means of the two trains, the paddle-steamer, the public bus, and the private car which I was obliged to use, it took four full days and involved four transshipments of myself and baggage from one conveyance to another. In this instance, however, I did not object to the inconvenience, as I was more than compensated by the beauty and interest of the country through which I journeyed.

In Jinja, third in importance among the towns of Uganda, about 50 miles from Kampala, I was forced to spend two days waiting for a train that would make connections with the weekly paddle-steamer that links Namasagali with Masindi Port, across Lake Kyoga.

The town, within walking distance of Ripon Falls, where the Nile tumbles out of Lake Victoria, seemed to be in the same ecological region as Kampala, and was, if anything, poorer in fruit. I found only avocados here very abundant in public and private grounds, and even along street borders, but not attacked by fruit fly.

At Busingiro, midway between the ports of Butisba, on Lake Albert, and Masindi, on Lake Kyoga, I found unexpectedly comfortable quarters, a very helpful and congenial host, and a pleasant and interesting field to work in. I arrived here on April 29.

The large house, once an hostel but now the official residence of Mr. W. J. Eggeling, Assistant Conservator of Forests, is situated on the very edge of Budongo Forest, a mass of trees fifteen miles long, around which other smaller masses center to form Busingiro Forest. It was, therefore, a simple matter involving no question of transport, for me to spend all my time in the field. Alone sometimes, and sometimes with my host, I did this every day for two weeks, and collected a considerable quantity and variety of fruit. Much of this was attacked by fruit fly, but I found that while other varieties might abound the only two fruits which yielded likely looking parasites were very scarce. These were Chrysophyllum albidum Don., and Solanum naumannii. The first, of which all the fruit obtained--two dozen fruits--came from a single tree, showed a small incidence of attack by C. colae Silv., and C. punctata Wd. (Bul), and produced a single specimen of Opius n. sp. (Bula) and two of the cynipid, Ganaspis sp. (Bulb). The Solanum was heavily infested with Ceratitis n. sp. (Bu2), and yielded two parasites, an Opiine, Opius fullowayi Silv. (Bu2a) and a Chalcid, Tetrastichus ?



oxyurus Silv. (Bu2b), but the distribution of this plant in Busingiro was restricted to a small area where at the time of my visit the fruiting season seemed to be about over. Of this Solanum I succeeded in collecting only about ten pounds, from which emerged only 21 Chalcids and four Opiines. From one lot of the common Guava, about 20 pounds, I bred C. colae Silv. and C. rubivora Coq. (Bu3), but this fruit was also scarce here, as in most places we visited in Africa, and several other lots examined were not infested with fly.

From rose apple, Eugenia jambos L., a cultivated fruit of which Busingiro boasted six trees, I bred about thirty specimens of C. colae Silv. (Bu4), but no parasites. From a single infested avocado among many examined, I bred five or six C. rubivora Coq. (Bu5), but this single fruit was obtained from a native and may not have been grown in Busingiro proper.

Myrianthus arboreus, which was thickly infested with fruit fly in Amani, but was scarce there in quantity, in Busingiro turned out to be relatively abundant, but with only a small percentage of infestation. From about forty pounds of the fruit I reared 30 or 40 specimens of C. rubivora Coq. and C. colae Silv. (Bu6), no parasites. Maesopsis eminii Engl., a large tree predominant among the forest rim species of Budongo Forest, was fruiting heavily, but of the hundreds of fruits I examined none appeared to be stung by fly, though the olive-like fruit looked like a very suitable host.

Mr. Eggeling aided me greatly in all my efforts to obtain enough material, but he constantly reiterated his opinion that my stay in Busingiro was ill timed. Being a proficient botanist, and having lived several years in Uganda, he should know, and from my results seemed to be right. It was impossible for him, however, to state definitely which months of the year might be the most favorable for our work. No one in Uganda had made observations on the incidence of fruit flies in forest fruits, and Mr. Eggeling had only a general notion of the time of maximum fruit abundance, never having kept specific notes on the subject. The season from October to January, he thought, would probably have produced a greater quantity and variety of fruit than May, the month during which I was in Busingiro. Though as it turned out it would probably have been useless to prolong my stay in Busingiro, I had not at first expected to have it limited to three weeks. That it was eventually so shortened depended on the fortuitous circumstance that early in May Mr. Eggeling was required to leave his post on an extended survey of another district. He then gave me the option of remaining in his house by myself or of going with him on the tour. Because my work in Busingiro showed but doubtful prospect of success, and because in any case the inaccessible location of the place made it almost impossible for me to remain any length of time without an automobile or some other means of transport of my own, I decided to go with Mr. Eggeling. I had his assertion that we were to travel through the richest wild-fruit district of Uganda, and, of course, his offer to facilitate in every possible way the study and collection of this fruit.

On May 10, crowded in the front seat between the household's dog and its negro cook, we left Busingiro in what in Africa is called a "Box-body", loaded to capacity with an enormous volume of necessary impediments. I had previously made arrangements with Mr. Eggeling's assistant to have him mail to Krauss, in Nairobi, all the fly pupae which had emerged and those which were to emerge from the fruit which I had collected during three weeks in Busingiro.

The first day took us to Butiaba, a port on Lake Albert and thence via the sizeable steamer CORYNDON, across the lake and down a portion of the White Nile to Pakwach in the West Nile Province of Uganda. We were now in a section of Uganda which, though rather thickly populated by natives, is almost completely undeveloped. Where roads, though surprisingly good, are few, and where apart from natives, the population is reduced to a handful of scattered government officials. We depended for shelter on "Rest Camps", well kept and pleasant, though crude, compounds of native manufacture located at every fifteen or twenty miles along the road for the use of government officials on tour. For food we depended upon our own cook and the limited variety of victuals which he could succeed in obtaining from local natives and small "Dukas" stores which in every settlement we touched were run by East Indians. Water was in many places as scarce as food, and always much worse. We made use of a great many rest camps, almost every night a different one, but the principal settlements we passed were, in order, Pakwach, Arua, Moyo, Larope, Gulu, Lira, and Soroti. In a map showing these (most of them will not be found in the ordinary map) it can be seen that our course ran approximately parallel to the Blue Nile and the longer axis of the West Nile Province from Pakwach to Larope, that we recrossed the Nile at Larope, leaving the West Nile Province there, and thence travelled at a right angle back again into the Northern Province. As the whole trip was done in a leisurely manner, covering never more than forty or fifty and usually only twenty or thirty miles a day, I had every opportunity to examine and collect fruit along the way. The entire course of the journey lay along country of a different nature than that seen in Busingiro. Though it is dangerous, perhaps, to summarize the matter, I would say that we travelled mainly through three ecological zones. The first comprises a part of the gently sloped basin of the Nile, and we saw of it only a small area on the west side of the river near Pakwach. Grass, at the time we were in this zone, was of the dry ready varieties, not over a foot or two in height and not dense of growth, in keeping with the relative aridity of the region. Other vegetation consisted of small trees and bushes, and it was invariably concentrated into clumps of from ten to fifty feet in diameter, which stood exclusively on old or abandoned termite nests. Characteristic plants of these clumps were a limited number of thorny acacias, asparagus grass, several Apocinaceae, particularly Carrissa edulis Vahl., Tamarindus, and a very striking candelabra-like Euphorbia. A few old and fire-scarred African ebonies were scattered here and there.



My observations agreed with Mr. Eggeeling's assertion that this zone at another time would have proved a desirable field for investigation. I found it rich in fruit-bearing varieties of plants. It was evident, however, that we had not arrived at the proper time to derive full benefit from their production. Of the most abundant species, *Tamarindus* had long since passed the fruiting season, and only a few dry pods remained in each tree. *Carissa edulis* and a species of *Zizyphus* on the other hand, were just beginning to ripen, and although their bushes were large and fairly abundant, I succeeded in collecting only one or two pounds of their fruit. Evidently in season at the time, but much scarcer than the fruits mentioned above, were *Capparis erythrocarpa* Isert. and *Balanites aegyptiaca* Del., but neither these scarce fruits nor the more abundant ones seemed to be attacked by fruit fly in Zone number one, although on one occasion I saw two specimens of some *Ceratitis* on a leaf of *Tamarindus*.

The second zone through which our journey carried us was, unfortunately, at once the most extensive and the least favorable for my work. It consisted, so to speak, of the back-bone of the West Nile Province, a vast undulating plain 1,000 to 2,500 feet above sea level, traversed by us along almost its entire longitudinal axis, since we entered it first some thirty miles west of Pakwach and did not leave it until May 20, when we turned east again at Camp Maracho, thirty miles north of Arua. In this zone we covered miles and miles without seeing anything but grass and a few paltry native plantings of young trees, which it is hoped by the Government will eventually provide the nuclei of larger forest areas. At one time this land was thickly forested, but now apart from a scattering of isolated specimens, I saw only two places where trees were to be found in any abundance. These wooded areas covered but a few acres each and extended in both cases along the margins of deep and narrow stream beds. Species of *Ficus* and *Erythrina* seemed to be of special importance in their composition, and I found in them only one fruit which might have been a host of fruit flies. This was a small Sapotaceous species, of which every fruit I found had been opened by Horn-bills.

We first entered the third zone some miles east of Pakwach. It coincided here with the eastern escarpment of the Nile Basin, and as the escarpment at this point is steep and narrow, we were out of the zone again within a few hours. When we entered it again, West of Camp Maracho, we remained in it for most of the remainder of our trip to Soroti. Because of soil differences or other conditions of which I am ignorant, the third zone evidently widens in the northern end of the West Nile Province and occupies there all of the Nile Basin, completely eliminating, as far as I could see, the well defined Zone number two, which I had explored in Pakwach. Topographically the third zone consisted of rolling plains occasionally interrupted by jutting promontories of rock. The soil was generally shallow, mostly stony, and often not well drained, but judging from native plantings it was rather fertile.

Vegetation consisted of sparse grass, rather thick brush and an abundance of a considerable variety of small to medium trees. Among the trees, Tamarindus, Acacias and Euphorbias had completely disappeared, and their place had been taken by other species less well adapted to arid conditions. Borassus palms, Borassus flabellifer, were in some places numerous and in one extensive, though sharply limited area, they grew to the exclusion of everything else. Butyrospermum niloticum Kotschy, though never to the exclusion of other species, was also very abundant in certain areas, but in general the predominance of any species or group of species was not clearly apparent. Butyrospermum niloticum is a typically Kotschy, though never to the exclusion of other species, was also very abundant in certain areas, but in general the predominance of any species or group of species was not clearly apparent. Butyrospermum niloticum is a typically sapotaceous fruit. About the size of an egg, with a rather thin and soft skin and a good amount of rich creamy pulp, in spite of a large seed, it appears to be an ideal host for fruit fly. Advance reports of its abundance in the West Nile Province had been a factor in my decision to undertake the trip I was now on, but now again as happened too many times during our expedition, I was to be disappointed. Butyrospermum was indeed abundant, and though in so doing I should have had to compete with natives, who use the fruit for food, I could have collected them by the thousands, but they proved to be absolutely untouched by fruit flies of any kind. In several hundred fruits examined at various places along the road, and in three collected and stored lots aggregating some 100 specimens, I was unable to find even traces of fly damage.

Next in abundance to Butyrospermum among those fruits which seemed to me potential hosts of fruit flies, came Sclerocaria birrea Hochat, resembling small apricots and of very pleasant taste. The abundance of these fruits, particularly near Camp Laufuri, would have made them very useful if they had been infested by fly. Unfortunately this was not the case. Vitex, either mediensis Oliv. or schweinfurthii Bak., a semi-edible, olive-like Verbenaceae, was found several times. In the only place where it was abundant near Amugo, it was just beginning to ripen and scarcely five pounds of the fruit could be gathered. It proved to be infested by Tridacus pectoralis Wlk. (Ug1), of which ten specimens were reared. Capparis erythrocarpa Isert., a very thorny rambler with a red fruit, similar in size and composition to a small Granadilla, was seen once near Pakwach, where it was still green, and it was met again twice in isolated plants, once near Awach and once near Soroti. In both the latter cases all the fruit available was collected, and in the last about 100 specimens of the fruit yielded 40 specimens of Ceratitis n. sp. and Themaristera laticeps Loew. (Ug2).



From a dozen trees of Kimberia americana L., an introduced Olacaceae of small habitus, with yellow, acid, leathery skinned, semi-edible, cherry-like fruits, I collected about ten pounds near Nembi, shortly after entering the third zone the first time, but for some unknown reason I was unable to rear beyond the pupal stage a Trypetid with which these fruits were infested.

At Soroti on May 31, Mr. Eggeling and I came for the first time in twenty-one days to a point touched by regular lines of transport. I could have gone on with him to explore other portions of the North Province, but the prospects were alluring only from the standpoint of personal pleasure, and at Soroti, on June 1, I boarded one of the weekly trains which connect at Tororo with the regular Nairobi-Kampala line.

As an example of the difficulties which may beset the travels of an entomologist in Africa, I remember the fact that at Soroti, a town of two or three thousand inhabitants, advertised in railway prospectuses as a railroad terminal, the station is at least eight miles from the rest house and it is only occasionally that one can hire a car to negotiate the distance, depending on the fickle temper of one of the Indian "Duka" owners. In my case, had it not been for Mr. Eggeling's great kindness in extending his stay at Soroti one day longer than necessary just for my benefit, I would have been forced to organize a whole day's "safari" simply to carry my baggage "from the hotel to the station", a matter which elsewhere costs a dollar and takes fifteen minutes.

Arriving again in Nairobi on June 2, I found Mr. Krauss in receipt of an unexpected cable of May 3 which enjoined our prompt return to America, if we had not found an adequate supply of parasites by June 15. I also found that during my absence he had greatly increased his supply of fruit and had on hand small quantities of more than twenty varieties of fruit, a considerable quantity--around 80 pounds--of one Strychnos species, and three or four thousand fly pupae from Strychnos and other sources. The Strychnos species, an undetermined Loganiaceae related to Nux-vourica, was for the most abundant of the fruits from which we succeeded in rearing parasites. Self propagated in Nairobi and its environments, and in many places planted for shade or border, the medium-sized trees produced large quantities of a small, yellow, berry, even during the latter part of Krauss' stay in Nairobi. Yet its abundance would be greater, we were told, at the height of the season--around the middle of July, and it was a matter of regret to Mr. Krauss and myself that neither our orders nor the shipping schedules permitted one of us to remain in Nairobi until that time. Even without increase of the quantity of fruit available, we felt a probable increase in parasitism was bound to greatly enhance our chances of getting live material to America later in the Strychnos fruiting season.

As we believed the material on hand represented as large a quantity as was likely to be available in Nairobi at any one time during the next few weeks, we proposed by cable to Washington that one of us should personally accompany a shipment to Hawaii by way of the Orient, rearing parasites from it enroute. But the proposition, because it would have entailed the use of one or more foreign boats, met with refusal and was dropped. Even had it been accepted, notification of its acceptance, if it had taken as long as that of its refusal to get to us, would have arrived too late to enable us to take advantage of the exceedingly rare coincidence of sailing dates which we had considered in connection with our request. Inquiry at this time disclosed the fact that no passage on American boats would be available from either Kenya or Tanganyika by any route for several months. Forced, therefore, to act in accordance with our cabled orders of May 3, rather than with the standing rule that United States employees must always travel on American boats, we booked passage by the earliest available steamer from Mombassa. This was the SS BERNARDIN DE ST. PIERRE of the Messageries Maritimes, leaving Mombassa on June 24.

We still had three weeks to use in Africa, and as Mr. Krauss seemed able to handle his material in Nairobi, abundant as it was, I left on June 4, bound on a second visit to Arusha. I believed that during my absence in Uganda coffee would have ripened and developed into a source of parasites, but in this I was mistaken. The coffee season, I found, had barely begun. Coffee was not as easily obtainable as it might have been three or four weeks later. In some plantations there was none yet ripe, and in others the crop was still in the stage where it took a man three or four hours to pick a five-gallon-can-full. Besides, fly incidence was very low, so that from a total of more than 100 pounds of coffee berries from three different sources, I was able to rear only four or five hundred flies. These were of two different species, C. capitata Wd. C. rubivora Coq., and C. colae Silv. (Aru7) (Aru8).

Of the parasites which Ritchie mentioned in the Annual Report of the Tanganyika Department of Agriculture for 1934, page 77, I saw nothing. Plantation men agreed on the fact that incidence of the fly in their coffee is small at the beginning of the season but usually increases to a very high percentage towards the end. They knew nothing of parasites, but spoke of gathering handfuls of fly larvae in washing tanks as an annually repeated experience.

Of fruit other than coffee I was able to obtain only a large quantity of a wild Peponium species, about twenty pounds of common guavas and a few specimens of Anona muricata. Neither the collected Anonas and guavas, nor many examined in the field, appeared to be attacked by fruit fly. From the Peponium, as I had already done during my first visit to Arusha, I reared a great many Tridacus pectoralis Wlk.



T. punctatifrons Karsch., and D. eclipsis Bez.? (Arul). No parasites. During this stay in Arusha the weather was continuously cold and rainy. I was told it would be so until the end of July or the middle of August.

On June 23, I left Arusha for Mombassa. On the afternoon of the next day, joined by Mr. Krauss, we sailed on the first lap of our return to the United States.

Neither the pupae from Strychnos nor those from other sources which Krauss had already obtained during my passage through Nairobi, on June 4, had proven heavily parasitized. On sailing from Mombassa, therefore, we had no large quantity of living adults in our care, only about 50 individuals of two species of Opius (Na1a) and (Na1b) from Strychnos, and a similar number from various other sources. We had, however, a large quantity of pupae obtained by Krauss during the last three weeks previous to his departure from Nairobi, and in addition we had about sixty pounds of freshly collected Strychnos fruit and forty pounds of coffee berries. The total quantity of pupae from miscellaneous minor sources was not great--around 500 pupae. But from Duranta we had 200 more, 200 from coffee and from Strychnos five half-filled one pint fruit jars. As little of the material was fresh and all had already endured unavoidably torrid conditions on the way to and in Mombassa, it was not thought worthwhile to place it in refrigeration. The Strychnos fruit was probably spoiled before going on board, but coffee kept well and produced 400 pupae, which were in good shape on arrival in New York, but which in accordance with quarantine rules were discarded at the entrance to the harbor, the dissection of a few having previously shown a very small percentage of parasitism.

The Strychnos pupae (from Trirhithrum occipitale Bezz., we believe) were evidently very lightly parasitized by the Braconids.

Opius spp. (Na22a) and more heavily parasitized by the Chalcid, Tetrastichus spp. (Na22c). Of two other Braconids, (Na22b) Opius sp. and Microbracon celer var. (Na22d), the parasitism was insignificant, resulting in the emergence of not more than half a dozen representatives of each species. In all about 200 Braconids had been produced by the Strychnos pupae on board, and some 2,000 Chalcids, but on arrival at Port Said we had left less than 100 Braconids and only two dozen Chalcids. Only two more Braconids emerged beyond that point, and no more Chalcids. Our miscellanea was also practically exhausted during the first ten days aboard, producing 200 parasites of various kinds, of which one-half were alive on arrival at Port Said.

We had expected to transship at Port Suez to the American SS PRESIDENT GARFIELD, but she proved to be five days behind schedule, and we stayed on the BERNARDIN DE ST. PIERRE, landing in Port Said. From Port Said, taking advantage of the GARFIELD'S delay we journeyed overland to Cairo and Alexandria and boarded our steamer at the later port on July 10. While in Egypt our material was detained in bond at Port

Said, but through the kindness of Mr. A. S. Fauzi, of the Plant Quarantine office, the rules were waived in the case of our living adults after the first day and we were able to carry these with us to Cairo and Alexandria, feeding them and attending to them as necessary.

In Cairo we were very well received at the Ministry of Agriculture and spent a useful morning in the company of Dr. Hassan, who permitted us to inspect the entomological collection and explained to us some important work he had been doing on the internal morphology of Ceratitis capitata. He told us that within the year he expected to start work on certain biological aspects of the fruit fly problem in Egypt, but that in view of the undeveloped status of the fruit industry in that country he did not consider the problem serious.

The last parasite from the earlier emergences died near Marseille on July 19 and from that date to July 27 we carried no living adults, but on July 27 and 28 respectively a small lot of pupae from Duranta plumieri yielded two specimens, both males, of O. fullawayi Silv. (Na2). These were not fed after arrival in New York and died in five days. On the afternoon of July 29 we arrived in New York and our expedition had come to an end.

#### OBSERVATIONS AND RECOMMENDATIONS

1. - Among the minor vexations met in Africa by the members of our expedition the most exasperating were usually connected with the question of transport. Trains, and in some cases, even buses were available to carry us over the longer steps of our journey, usually with only a moderate degree of discomfort or delay. For the shorter steps, however, the actual trips into fruit growing areas for the purposes of exploration and collection, the securing of conveyance was always difficult and very often impossible. It is felt by the members of the expedition, therefore, that one of the soundest recommendations we can make to future investigators of the areas we visited is to provide themselves early with their own means of transport. The matter involves no unreasonable expense. Though the cost of petrol is considerably higher in East Africa than in the United States, an automobile of American make can be bought for the same, or in some cases even lower price than in the American market, and a driver, who can also be pressed into work of other nature, can be hired for 35 shillings a month, plus a meager allowance for his board. In addition, as the network of practicable roads is far more extensive and complete than that of the railroads, the car can be used with advantage to the exclusion of trains, and depending on the amount of use which may be made of it, may soon pay for itself.



2. - For future work of exploratory nature we recommend among the fields with which we became acquainted, Busingiro Forest and the West Nile Province of Uganda. These two areas were visited at a season of the year particularly unfortunate for the conduct of fruit fly research. It was obvious, nevertheless, that at times fruits and berries, mostly native, must be at least as abundant here as Mr. Krauss found them to be in Nairobi. Our collections besides evince the presence in these areas of at least one *Ceratitis* in each, and their scarcity in the fruit available to us points to a favorable degree of control by parasites or other factors.

Suitable headquarters could be found in both of these areas if the work should demand an extended stay, in Soroti for one area, and in Masindi for the other. From both of these places shipments could be made once a week by train to Nairobi. In the conduct of work in these areas the use of an automobile would be not only necessary but essential, and the car would have to be obtained elsewhere, for neither Soroti nor Masindi can provide one.

From information gathered on the spot, meager though it is, it is possible to judge that the best season for fruit fly work in these areas would lie between the months of September and December.

3. - Should any of the parasites we found in Nairobi prove of promise and it be decided to introduce them to Hawaii, no insurmountable difficulty will be presented by the task. Success, however, will probably unavoidably necessitate the making of personally conducted shipments of material by the direct orient route to Hawaii, and if the work is undertaken by United States Government men, it will be necessary to empower them in advance to disregard, if necessary, the official restriction on travel by foreign boats.

4. - Mr. Krauss' observations and information which he gathered from various sources incline to show that a season more favorable to our work in Nairobi and the Kenya Highlands than the time we were there would have been from the middle of July to late September. The greatest abundance of *Strychnos* fruit, and probably the highest incidence of parasitism, occurs towards the middle of July.

#### ACKNOWLEDGMENTS

Besides the persons mentioned in the body of this report there were many others to whom the members of our expedition became indebted. We have reason to be particularly grateful, among these, to Mr. D. G. Smith, Mr. George Kotuvides, Mrs. E. W. Rydon, Mr. E. W. Kroskill, Mr. P. Van Jaarsvelt and Mr. Kenyon Ulyate of Arusha, to Mr. John Keogh, American Vice Consul at Nairobi, to Mr. R. E. Sangster of the Uganda Forest Department, and to Drs. H. S. Barber and J. C. Bridwell of the United States National Museum.





## FRUIT FLIES AND THEIR PARASITES IN BRAZIL, 1935-36

By D. T. Fullaway

This is an account of a one-man expedition to South America to secure fruit fly parasites and predators for introduction into the Hawaiian Islands where two species of fruit flies, the Mediterranean fly and the Asiatic melon fly, have continuously for many years destroyed large quantities of fruits, despite all previous efforts to curb their destructiveness. The South American venture, it may be stated here, was merely one of a number of similar expeditions made to various tropical regions of the world for fruit fly enemies and was perhaps from the beginning less promising than any of the others, since the American fruit flies seem to constitute a distinct group without close relationship with the fruit flies of the regions where the Hawaiian pests are indigenous or whence they have been derived. The interest in South America as a source of natural enemies for fruit flies comes from the published accounts of George Compere, who visited Brazil in 1904 and claimed to have obtained by strenuous collecting and breeding work, large numbers of valuable parasites and predators which were taken to West Australia, introduced and propagated for one season but eventually lost sight of through neglect. At all events and in spite of the uncertainty surrounding Compere's work it was unquestionably ascertained that parasites and predators were present in Brazil and could be easily obtained; and since the Mediterranean fly is always present alongside the American fly in the Rio region visited by Compere, as is attested by many visiting entomologists, as well as the local ones, it seemed a good place in which to begin with the work. There I arrived in October and there I collected assiduously for seven months with varying success. It was pioneer work to some extent for there was little in the literature of entomology that was useful for application to the definite problem in hand and personal contact with local entomologists gave me only hope, little of assurance with regard to the ultimate success of the enterprise.

I was struck at once upon arrival with the similarity of the climate and fruit products of the two regions, that is the state of Rio and Hawaii, and there was a definite promise of a succession of fruits throughout the year which would enable me to carry on the investigations leisurely and carefully and without that anxiety which afflicts much of this work as to the proper judging or timing of the critical period when the hoped for enemies would have to be transported from one country to the other.

My method of handling the collected material was to put the infested fruits over sand in cylindrical metal containers 14" high and 10" in diameter, wire screen on the sides above the sand and cloth cover at the top, and wait two or three days until the fruit fly larvae had left the rotting fruit and descended into the sand to pupate. The sand would then be screened and the pupae collected, cleaned, counted and put in glass vials 4" high and 1" in diameter, cotton stoppered, to await the

emergence of the parasites from the ones parasitized or fly from the unparasitized. The country was scoured for fruits and much was obtained in the Rio markets and the Rio Botanic Garden. For the temperate climate fruits visits had to be made to the mountain towns, Petropolis and Therasopolis; the San Concalo Alcantara regions, Novo Igassu and Belem and Barro Tijuca proved to be the best regions for obtaining considerable quantities of fruits; some coffee berries were obtained from the Leite Guimares Brothers, Fazenda at Andrade Pinto. The last four months I had assistance from a Department of Agriculture worker, Mr. Abreu, who was assigned to me out of the office of the Plant Quarantine Service. The fruits handled in the order of handling were peaches, pitanga cherries (Eugenia uniflora), guavas, jaboticaba, sapota, jambolanes (Eugenia jambolana), jelemons, mimusops, cashew nuts, reedia fruits, kamani (Terminalia catappa), cajamangos, (Spondias dulcis), coffee, caja mirin. Some of these fruits were ripening during the whole seven months of my stay in Brazil, others like the peach, coffee, terminalis seem to have definite fruiting seasons, longer or shorter, according to the nature of the fruit. With regard to infestation, I was prepared by advices received from Mr. Kisliuk, who with Mr. Cooley had conducted a fruit fly survey in South American countries several years previously, to expect a mixed infestation in any fruit handled, and this seemed to be the rule with many of the fruits handled in the earlier period of my work, fruits like peaches, guavas, etc., the predominant species being always the indigenous fratercula. Later, however, it seemed to me that the Mediterranean fly, which is an emigrant to Brazil (of long standing, however,) infested fruits exclusively (examples: terminalia fruits, coffee). One fruit, that of the mimusops trees occurring in the Botanic Garden (not an indigenous plant, I believe) yielded only Anastrepha serpentina. The caja mirin yielded all fratercula and the larvae were all large, plump, well-conditioned ones which showed little disposition to leave the fruit and often had to be removed forcibly to expedite handling the material.

I was very much perplexed in the earlier months in the work at the low yield of parasites from all the heavily infested fruit handled. I believe this can be explained partially by the nature of the fruits. Fruits like the peach, guava, etc., are largely pulp and the worms bore deeply into this and get beyond reach of the parasite's ovipositor (Opilne parasites always oviposit while resting on the outside of the fruit. The worm is located by palpation and when the parasite is in proper position the ovipositor is thrust through the skin and underlying pulp and inserted in the worm, the egg being placed internally.)

When parasites were eventually secured in large numbers it was the end of summer and that might very well be an explanation too, since most insects reach their population peaks at that time.



The principal parasite of the fruit flies reared during the seven months stay in Brazil has been determined as Opius cereus Gahan. It is a light colored species with long black antenna and ovipositor. On several occasions in the earlier months of the work another species was obtained with long ovipositor but darker body and wings. In the latter months of the work a third species appeared having a short ovipositor (not extending beyond the tip of the abdomen) and dark maculations on the mesothoracic notum. This species has now been determined as Opius mellus Gahan. During the whole progress of the work a small Cynipid was encountered and whenever possible these were collected and utilized. Later on another larger species was reared also. In addition there were the usual diapiids and chalcids, the latter probably *Nasenia*, a common dipterous pupal parasite. It was a very common occurrence to find staphylinid beetles in the fruit containers also and these were always collected and utilized.

Having described as well as possible the methods pursued and noted my observations during the progress of the work, I wish to turn now to giving some information culled from my daily work report indicating the volume of the work and the result in parasite production. This is largely put in tabulated form to facilitate its inspection.

Began with 11 containers which were increased gradually to 23.

No. 1		<u>Lots of Fruit Handled</u>	
		October (20 days)	17
		November	10
		December	16
		January	36
		February	29
		March	36
		April (22 days)	37

  

No. 2	<u>Fruits Employed</u>	<u>No. of fruits</u>	<u>No. pupae obtained</u>	<u>No. parasites obtained</u>
	Peaches	1,859	4,995	31
	Pitanga cherry	8,230	10,960	730
	Guava	718	1,945	8
	Carambola	829	903	11
	Jaboticawa	1,092	60	0
	Sapota	18	73	0
	Mountain apple	171	498	46
	Jejemon	341	0	0
	Mimusops	97	512	0
	Reedia	70	76	0
	Kamani	797	2,176	0
	Cajamang <sup>o</sup>	113	88	0
	Coffee	7,100	243	0
	Caja mirin	735	4,131	581
	Araca	650	540	0
	Totals	22,820	27,198	1,407

Highest percentage of parasitism obtained from any single lot of fruit 45.

Highest percentage of parasitism obtained from any single fruit 16.

Average percentage of parasitism of all fruits 5.

Highest percentage of parasitism obtained from any three fruits 8.7.

Division of parasites by sexes: Females 866; males 552.

It will be noticed in examining the data presented above that a number of the fruits were very little infested and that from some no parasites were obtained. This is very significant to me in the case of *Terminalia* and coffee, since these two fruits, at least all the samples I worked with, contained only Mediterranean fruit fly larvae, and apparently are not attacked by the other species of fruit fly in Brazil. If the common parasite could not be recovered out of more than 2,000 fruits there is a likelihood--it seems to me very likely--it is not attracted or cannot accommodate itself to this African trypetid. This possibly was considered in the disposition of the collection of parasites brought to the United States.

In regard to the disposition of the parasites, the first obtained were used chiefly in attempting breeding, the hope being entertained that the small number in hand could be increased so that a considerable shipment could be made weekly by air express to Hawaii. Lack of success with this attempted propagation led me to consider other dispositions. The first shipments to Hawaii consisted chiefly of two scale-feeding Coccinellid beetles, Staphylinid beetles, obtained in connection with fruit infesting diptera and pineapple mealybug parasites. One such shipment was made in October, 4 in November, 4 in December and 4 in January. The lack of success in transporting the delicate scale-feeding Coccinellid beetles over the extra long and hazardous route to Hawaii led me to consider Puerto Rico as a possible way station in connection with the projected transportation of the fruit fly parasites. Arrangements were made with Dr. K. A. Bartlett, of Mayaguez, to handle the parasites and shipments began in January, 5 being made that month. The shipments included altogether 47 females and 25 males of *Opius cereus*. Only one shipment was made in February as the yield of parasites that month was very poor. This shipment consisted of 13 individuals, 5 males and 7 females. The March yield was hardly better, consisting of 9 females and 6 males, which were sent in two shipments on account of a spread in the emergence. April gave such great promise of heavy parasite emergence that plans were made at once to follow the instructions received earlier with regard to carrying the parasites by hand to their destination instead of intrusting them to commercial carriers, which apparently had solved the transportation problem in the case of the African expedition, but inasmuch as steamer transportation could not be obtained until the 23rd of the month one shipment was made by air express in advance of my departure from Rio, consisting of two cages packed with 50 individuals each, and this shipment was made directly to Hawaii. Information has been received that the shipment reached San Francisco in excellent condition.



On the 23rd of April I closed up the laboratory, which had been in operation since October 11, and took passage on the SS AMERICAN LEGION bound for New York City, with all emergence up to that time and with considerable infested fruit and host material which was worked over on the ship in the course of the voyage, some of it even being used in cages in attempts to increase the number of parasites by breeding back. An extra stateroom on the ship was used as a temporary laboratory, the insects cleaned and fed daily, all emergence of adults secured and confined in tubes, jars, cages, etc., the host material gradually being eliminated as the emergence neared completion. By May 5 about 3,000 pupae remained from which no emergence had taken place. To save the parasites in these pupae they were opened one by one, the unparasitized individuals being discarded, the parasites (pupae) saved. Arrival at Brooklyn was on the 6th at 3:30 in the afternoon and the parasites, pupae and adults, to the number of one thousand or more were landed, passed through Customs, and taken directly to the Moorestown, N. J., laboratory, whence they were shipped on the 7th and 8th of May, shipments consisting of 400 opiines and over 100 staphylinid beetles to Hawaii, and the remainder of the opiines, the cynipids and proctotrupids to Puerto Rico. The reason for diverting the bulk of the opiines to Puerto Rico is found in the inference drawn from the results obtained from the handling of coffee and Terminalia fruits from which no parasites were obtained although they were heavily infested and almost exclusively with Mediterranean fruit fly. (This, however, may not be correct, as it has been found that Opius cereus will attack the Mediterranean fruit fly and at least one generation has been reared on this host in Hawaii.)

To date no report has come from the Hawaiian shipments, although their safe arrival in San Francisco has been verified. Information has also been received from Puerto Rico that the parasites shipped there arrived in good condition and the Bureau representatives there were proceeding directly with the liberation of a portion of the collection, retaining the remainder for propagation to increase their number.

Later reports were as follows:

2 cages Opius cereus sent air-express from Rio on arrival in Honolulu contained 31 females, 3 males, alive and in good condition.

4 cages Opius cereus and Opius bellus Gahan, sent air express from Moorestown, N. J., on arrival in Honolulu contained 117 males and females, alive and in good condition, of which 62 were taken to the Kona district of Hawaii for liberation and 55 were held for rearing.

8 cages Opius cereus, Opius bellus Gahan, Eucoilas and Diapriids sent by air express from Moorestown, N. J., on arrival in Mayaguez, P.R., contained 164 males, 343 females opiines alive and in good condition, some parasite pupae tardy in emergence, 2 Eucoilas and 15 diapriids.

In addition to the fruit fly work, collections were made of pineapple mealybug parasites and natural enemies of the cocoanut scale (Pinnaspis buxi). The former consisted of two encyrtid parasites, one being Hamblatonia pseudococcina Compere, the other Anagyrus coccidivorus Dozier; the latter, two promising coccinellid beetles, Pentilia egena and Ladoria desarmata. During the period of my stay in Brazil 10 shipments of the mealybug parasites were made to Hawaii and 5 to Puerto Rico. Thirteen shipments of the coccinellids were made to Hawaii and one to Puerto Rico. The beetles were available only for a short period of several months' duration. The pineapple mealybug parasites were obtainable all through the months of November, December, January and February. The picking season of the fruit, which was the part of the plant used in searching for the "mummies" (parasitized individuals) of the mealybug ended in February and material could not be readily obtained after that.



FRUIT FLIES AND THEIR PARASITES IN MALAYA, CEYLON, AND INDIA  
1935-36.

By Fred C. Hadden

This paper is a chronological report on an eight-months trip through Malaya, Ceylon and South India in search of fruit fly parasites. The Trypaneidae (Fruit flies) are represented in Hawaii by only two species of economic importance, Ceratitis capitata Wied., the Mediterranean fruit fly in the subfamily Trypaninae, and Chaetodacus cucurbitae Coq., the melon fly in the subfamily Dacinae.

The subfamily Trypaninae is poorly represented in the regions visited, the only species occurring in numbers being Carpomyia vesuviana Costa in southern India where it infests jujube (Zizyphus jujuba) fruits. This fly and its parasites were not available in May and June as the trees were not fruiting. Jujube fruits begin to mature in July.

The subfamily Dacinae is well represented in the regions visited, with the maximum number of species being found in India. Chaetodacus ferrugineus F. (and its varieties) is the common fruit fly infesting fruits in Malaya, Ceylon, and India. It was found from sea level up to 7,000 feet altitude at Ootacamund in the Nilgiri Hills, South India. Nearly all kinds of edible cultivated fruits were found infested by this species.

In Hawaii, coffee and kamani (Terminalia catappa) fruits are heavily infested by Ceratitis. No fruit flies were found infesting these fruits in the regions visited.

Following is an itinerary of the trip:

MALAYA - SINGAPORE

November 29, 1935. Sailed from Honolulu on the SS PRESIDENT HAYES, arriving after 29 days in Singapore on December 28. Singapore (8 days). Found Chaetodacus ferrugineus F. (or its varieties) in small numbers in Averrhoa carambola, oranges, Eugenia uniflora, and guava. Opius fletcheri? and Opius persulcatus were bred from larvae in these fruits, and were observed ovipositing in Carambola and Eugenia fruits in the Botanical Gardens. The "Melon Fly", Chaetodacus cucurbitae Coq., and its parasite, Opius fletcheri were bred from cucumber, Momordica charantia and Luffa acutangula. These cucurbits were found in Chinese vegetable gardens located in various directions around Singapore at a distance of 6 to 10 miles.

MALAYA - KUALA LUMPUR

January 5, 1936. Left Singapore by train in the morning and arrived (after 9 hours) in the evening at Kuala Lumpur.

January 6 to March 26, 1936. (81 days) Investigated fruit flies around Kuala Lumpur, F.M.S. and Serdang, the Government Experiment Station which is about 20 miles from Kuala Lumpur. The main source of fruit fly material was Averrhoa carambola at Serdang. Chaetodacus ferrugineus was bred from Citrus, guava, Eugenia, Carambola, Chilli and ripe jak fruits (Artocarpus integrifolia). Most of the parasite material was obtained by clearing the ground under Carambola trees, then gathering the fruit in a pile on the ground under the trees, in the shade, where it was left for about a week. Then the fly pupae were dug from the soil by coolies. This was easily done because of the sandy nature of the soil in this locality. Pupae thus obtained always produced a higher percentage of parasites than those obtained by bringing fruit into the laboratory.

From these pupae were bred: Opius fletcheri, O. longicaudatus, O. persulcatus, Pachycrepoides sp., Melittobia indicum, Galesus sp., Spalangia sp., and Tachinaephagus sp.

Chaetodacus cucurbitae Coq., was bred from nearly all kinds of cucurbits, such as cucumbers, Momordica, snake gourd (Tricosanthes enguis) and Luffa acutangula. Opius fletcheri was the only species of parasite bred from melon fly in Malaya.

Chaetodacus umbrosus F. was bred from Jak fruit (Artocarpus integrifolia); Chaet. caudatus F. from cucurbits; and Chaet. dorsalis Hend. from citrus.

Guava was never found heavily infested with fruit flies, and never produced many parasites in any of the regions visited.

#### FIRST SHIPMENT OF PARASITES

During the last two weeks in March the work was concentrated on accumulating material for obtaining parasites to ship to Honolulu.

March 26, 1936. Left Kuala Lumpur with adult parasites and fly pupae from which parasites were emerging, arriving in Singapore the next morning, where parasites continued to emerge and were prepared for shipment.

March 28, 1936. Sent shipment of 1,100 parasites (3 species) to Honolulu on the SS CARTHAGE. They were transferred to the SS EMPRESS OF CANADA in Hongkong on April 3, and arrived in Honolulu April 17, 1936.

Only 15 specimens survived this trip of 21 days, as follows:

<u>Opius fletcheri</u>	1 male	1 female
<u>Opius persulcatus</u>	1 male	12 females
<u>Opius longicaudatus</u>	0 male	0 female



A few male O. persulcatus were bred from Ceratitis larvae exposed to parasites from this shipment, in the laboratory in Honolulu.

April 7, 1936. Sailed from Singapore on the SS PRESIDENT HARRISON after having been in Malaya 102 days.

#### CEYLON - PERADENIYA

April 13, 1936. Arrived in Colombo, Ceylon, 6 days after sailing from Singapore.

April 17, 1936. Left Colombo by train, arriving at Peradeniya in 5 hours. Twenty-six days were spent investigating fruit flies in Ceylon. Chaetodacus ferrugineus was found in numbers only in mango. It was parasitized by O. fletcheri and O. longicaudatus. Opius persulcatus is apparently not represented in Ceylon.

Chaetodacus garciniae (?) Bez. heavily infested Garcinia tinctoria, in the Botanic Gardens and was fairly well parasitized by Opius longicaudatus.

Snake gourd (Tricosanthes anguis) was heavily infested by melon fly which were parasitized by O. fletcheri and O. longicaudatus.

#### INDIA -- COIMBATORE

May 9, 1936. Left Peradeniya by train arriving after 36 hours at Coimbatore on May 11, 1936. Investigated fruit flies at Coimbatore, Ootacamund, Coonoor, Burliar and Kallar. Most of the parasite material was Solanum auriculatum berries from Coonoor. Fruit flies and their parasites were scarce around Coimbatore, due to an exceptionally long dry season, and to poor crops of fruits.

Dirhinus auratus Ashm. was bred from melon-fly pupae dug from the soil under cucumbers at Coimbatore. Only a very few O. fletcheri were bred from thousands of melon fly pupae.

Most of the fruit flies bred from Solanum berries were Chaetodacus ferrugineus dorsalis Hend. Chaet. ferrugineus incisus Walk. also emerged from Solanum in small numbers. Opius persulcatus was the dominant parasite here, as well as in Malaya. It occurs from sea level up to 7,000 feet, in both dry and wet regions, but is scarce in the dry regions when there are no rains.

#### SECOND SHIPMENT OF PARASITES

June 24, 1936. Left Coimbatore, India, with 46,500 fruit-fly and melon-fly pupae.

June 25, 1936. Arrived Peradeniya and picked up 14,780 more pupae collected by assistant Tikiri Banda under the direction of Dr. Hutson.

June 28, 1936. Sailed from Colombo on the SS NALDERA. Flies and parasites were emerging in large numbers from both the Indian and Ceylon material.

July 4, 1936. Left Singapore, having picked up 16,000 more pupae forwarded by Dr. Corbett from Kuala Lumpur.

July 8, 1936. Arrived Hongkong, 10 days from Colombo.

July 11, 1936. Sailed from Hongkong on the SS PRESIDENT COOLIDGE. A few Malayan parasites emerged after sailing from Hongkong. No flies emerged after July 18.

July 24, 1936. Arrived in Honolulu, one month after leaving Coimbatore, India.

The number of parasites surviving the trip, and the number bred enroute is shown in the following table:

Parasites Bred Enroute	:	Number	:	Percent
	:	Survivals	:	Survivals
1. <u>Opius persulcatus</u>	1,228	151		12.3
2. <u>Opius longicaudatus</u>	168	10		6.0
3. <u>Opius fletcheri</u>	540	29		5.3
4. <u>Dirhinus auratus</u>	420	150		35.7
5. <u>Spalangia</u> sp.	500	50		10.0
6. <u>Tetrastichus hogenowi</u> ( <u>Pachycrepoides</u> )	20	3		15.0
Total	2,876	393		

These parasites emerged from material as follows:

Fly pupae from:	:	Fruits	:	Ex Cucurbits
India		44,500		2,000
Ceylon		3,213		11,567
Malaya		13,000		3,000
Total		60,713		16,567

The 44,500 pupae from India included 2,500 from mango at Kallar and Burliar, the rest from Solanum at Coonoor.

The 13,000 pupae from Malaya were mostly from Carambola.



The 3,213 pupae from Ceylon were 2,794 ex Garcinia and 419 ex mango. The 11,567 were all from snake gourd.

Very few, less than one-tenth of 1 percent of the parasites from India and Ceylon, arrived alive in Honolulu, except the Dirhinus and Spalangia which were bred on Ceylon and Malayan pupae enroute. Over 95 percent of the parasites arriving alive in Honolulu emerged from the Malayan material.

Attempts at breeding Opius persulcatus on Ceratitis in the laboratory from this shipment failed, possibly due to the fact that larvae in fruit exposed to them were already highly parasitized by parasites already present in Honolulu. However, O. persulcatus, O. longicaudatus, Dirhinus sp. and Spalangia sp. were released in the field and may become established. The Dirhinus and Spalangia are still being bred in the laboratory. They have failed to parasitize dung-fly or house-fly pupae.

The following species of Fruit Flies were observed in the Orient:

	Species	Locality	Host
1.	<u>Chaetodacus umbrosus</u> F.	Malaya	Jak fruit
2.	" <u>cucurbitae</u> Coq.	Malaya, Ceylon, India	Cucurbits
3.	" <u>garciniae</u> Bez.	Ceylon, India	<u>Garcinia</u>
4.	" <u>diversus</u> Coq.	Malaya	Chilli
5.	" <u>correctus</u> Bez.	India	Mango
6.	" <u>ferrugineus</u> F.	Malaya, India	Carambola, Mango
7.	" " var. <u>pedestris</u> Bez.	Malaya	<u>Eugenia</u>
8.	" <u>ferrugineus</u> var. <u>dorsalis</u> H.	India	<u>Solanum</u>
9.	" <u>ferrugineus</u> var. <u>incisus</u> Wied.	India	Mango, <u>Solanum</u>
10.	" <u>ferrugineus</u> var. <u>versicolor</u> Bez.	India	Mango
11.	" <u>caudatus</u> F.	Malaya, Ceylon, India	Cucurbits
12.	<u>Dacus brevistylus</u> Bez.	Ceylon, India	Cucurbits
13.	" <u>longistylus</u> Wied.	Ceylon, India	Cucurbits



Parasites on Fruit Flies Observed in the Orient:

Species	Locality	Host
1. <u>Opius fletcheri</u> Silv.	Malaya, Ceylon, India	Cucurbits
2. " <u>incisus</u> Silv.	India	<u>Solanum</u>
3. " <u>persulcatus</u> Silv.	Malaya, India	Mango, <u>Solanum</u>
4. " <u>longicaudatus</u> Ashm.	Malaya, Ceylon, India	Mango, <u>Garcinia</u>
5. " <u>compensans</u> Silv.	India	Mango
6. <u>Tetrastichus hagenowi</u>	Malaya	Pupae in soil under <u>Carambola</u>
7. <u>Melittobia indicum</u> Silv.	Malaya	" " "
8. <u>Tachinaephagus</u> sp.	Malaya	" " "
9. <u>Galesus</u> sp.	Malaya	" " "
10. <u>Spalangia</u> sp.	Malaya	" " "
11. <u>Dirhinus auratus</u> Ashm.	India	Cucumber

The total number of parasites obtained was:

Month	No. of Fly Pupae	<u>Opius</u>	Other Parasites
January	3,646	603	0
February	6,396	469	1,387
March	15,625	2,517	2,363
April	18,000	400	200
May	25,000	15	0
June and July	103,000	3,943	920
Total	171,862	7,947	4,870

In all about 180,000 fly pupae produced a total of about 14,000 parasites.

The "other parasites" were:	<u>Pachycrepoides</u> *	3,522
	<u>Melittobia</u>	604
	<u>Tachinaephagus</u>	80
	<u>Spalangia</u>	30
	<u>Dirhinus</u>	96

(This does not include the Spalangia and Dirhinus bred enroute to Honolulu.) \* (Pachycrepoides = Tetrastichus hagenowi.)

Of the Opius about 30 percent were fletcheri, 65 percent persulcatus, and 5 percent longicaudatus. Only about 20 percent of the fruit handled was cucurbit material.



About 80 percent of the fly pupae was	<u>Chaet. ferrugineus</u>	or its var.
" 15 " " " " " "	" "	<u>cucurbitae.</u>
" 2 " " " " " "	" "	<u>caudatus.</u>
" 3 " " " " " "	" "	other species.

While C. ferrugineus or some of its varieties were bred from nearly all kinds of cultivated fruits in the Orient, it decidedly prefers Solanum auriculatum (or verbascifolium) and mango in India; mango in Ceylon; Carambola and Citrus in Malaya.

Momordica, Tricosanthes, and cucumbers were the preferred hosts of C. cucurbitae in the Oriental regions visited, however, any species of cucurbit may be infested.

The subject of fruit flies and their parasites is far from exhausted. A great deal of very careful breeding work must be done in order to determine whether or not there are other parasites that may be of use in control work. This type of work could not be done in the limited time of the trip.

Ceratitis capitata arrived in large numbers in Colombo, Ceylon, in a shipment of citrus from Palestine, in April 1936. Larvae, pupae, and emerging flies were present in large numbers. The ship anchored less than a quarter of a mile from shore, and infested boxes of fruit containing hatching pupae were even landed. Kamani trees and other fruits susceptible to Ceratitis were growing and bearing fruit in condition to be infested. Certainly this was not the first time this had occurred, and yet for some reason Ceratitis has not become established in Ceylon.

Papaya, figs, breadfruit, mangosteen, jambos, and rambutan are rarely infested in the Orient, and then only when dead ripe or after they are split open by falling to the ground.

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